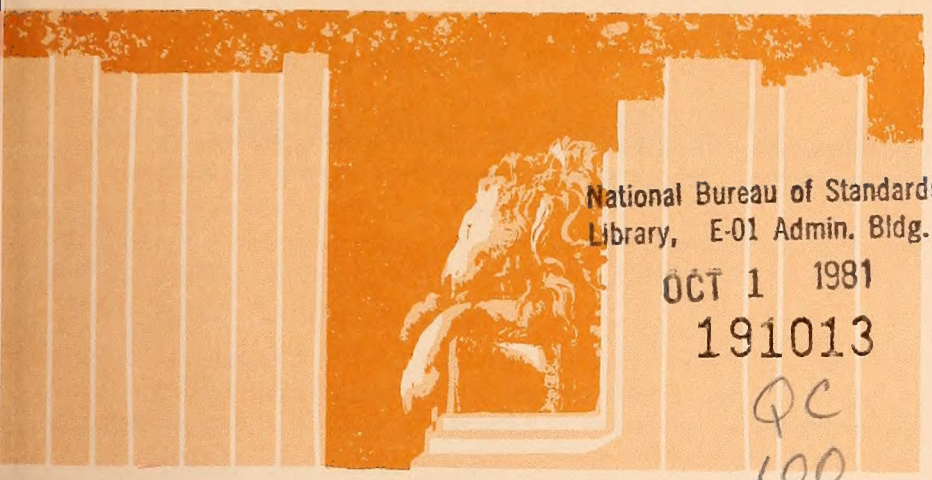
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Publications of the National Bureau of Standards



1976 Catalog

SP 305
supplement 8

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Institute for Computer Sciences and Technology, the Office for Information Programs, and the Office of Experimental Technology Incentives Program.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of the Office of Measurement Services, and the following center and divisions:

Applied Mathematics — Electricity — Mechanics — Heat — Optical Physics — Center for Radiation Research — Laboratory Astrophysics[2] — Cryogenics[2] — Electromagnetics[2] — Time and Frequency[2].

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement, standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; and develops, produces, and distributes standard reference materials. The Institute consists of the Office of Standard Reference Materials, the Office of Air and Water Measurement, and the following divisions:

Analytical Chemistry — Polymers — Metallurgy — Inorganic Materials — Reactor Radiation — Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services developing and promoting the use of available technology; cooperates with public and private organizations in developing technological standards, codes, and test methods; and provides technical advice services, and information to Government agencies and the public. The Institute consists of the following divisions and centers:

Standards Application and Analysis — Electronic Technology — Center for Consumer Product Technology: Product Systems Analysis; Product Engineering — Center for Building Technology: Structures, Materials, and Safety; Building Environment; Technical Evaluation and Application — Center for Fire Research: Fire Science; Fire Safety Engineering.

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in improving cost effectiveness in the conduct of their programs through the selection, acquisition, and effective utilization of automatic data processing equipment; and serves as the principal focus wthin the executive branch for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Institute consist of the following divisions:

Computer Services — Systems and Software — Computer Systems Engineering — Information Technology.

THE OFFICE OF EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM seeks to affect public policy and process to facilitate technological change in the private sector by examining and experimenting with Government policies and practices in order to identify and remove Government-related barriers and to correct inherent market imperfections that impede the innovation process.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System; provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data — Office of Information Activities — Office of Technical Publications — Library — Office of International Standards — Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

[2] Located at Boulder, Colorado 80302.

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Publications of the National Bureau of Standards 1976 Catalog

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Betty L. Burris, Editor

Office of Technical Publications
National Bureau of Standards
Washington, D.C. 20234

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Dr. Sidney Harman, Under Secretary

Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Acting Director

Issued June 1977

US

Library of Congress Catalog Number: 48-47112

National Bureau of Standards Special Publication 305 Supplement 8

To Accompany National Bureau of Standards Special Publication 305; and its Supplements 1, 2, 3, 4, 5, 6, and 7
Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 8, 728 pages (June 1977)

CODEN: XNBSAV

Issued June 1977

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1977

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Stock No. 003-003-01743-4), **Price $8.25** (Add 25 percent additional for other than U.S. mailing.)

PREFACE

The 75th anniversary of the National Bureau of Standards, which took place in 1976, saw the largest production of printed pages in the history of the Bureau. In the Bureau's regular or formal publications, the total was 48,279 pages, an increase of some 7,000 over 1975. In addition, grantee/contract reports (GCR) prepared by NBS contractors and NBS patents are reported for the first time. The overall total of pages reporting NBS and NBS-sponsored results amounted to 60,727 pages in 1976. About 79 percent of these were issued in the Bureau's own publications series; the other 21 percent in non-NBS journals, books, and proceedings.

The inclusion herein of citations for patents issued to NBS inventors, and for reports prepared under NBS contracts, will enhance awareness and accessibility of these important NBS outputs. Also included, as in past years, are citations for papers published in the Journal of Physical and Chemical Reference Data, which is published for NBS by the American Institute of Physics and The American Chemical Society.

All papers are cited by full title, author(s), place of publication, abstract, and key words. Permuted author and key word indexes facilitate use of the listings, as does the edge index on the back cover. Citations for papers published in the Bureau's formal program are organized by NBS publications series. NBS-authored papers in non-NBS media are cited separately in numerical sequence. In addition, for the convenience of specialists, a special section categorized by major primary subject area lists the titles for all NBS publications for 1976.

NBS papers published by the Government Printing Office are sold by the Superintendent of Documents and also, in microcopy form, by the National Technical Information Service (NTIS). During 1976 a change was made in the sales arrangements for the NBS Federal Information Processing Standards Publications (FIPS PUBS); these are now sold only by NTIS.

For the convenience of researchers, this issue contains information on previous NBS catalogs, and on the availability of NBS papers published in past years. Also included, for completeness, are those NBS papers published prior to 1976 but not reported in previous issues of this annual catalog. This 1976 catalog, Supplement 8 to NBS Special Publication 305, was produced by means of computer-assisted photocomposition.

W. R. Tilley
Office of Technical Publications

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1. NBS PUBLICATION PROGRAM

1.1 INTRODUCTION

The formal publication of the National Bureau of Standards—some papers in 1976 provide the primary means of communicating the results of NBS programs to its varied technical audiences, as well as to the general public. Publications thus constitute a major end product of the Bureau's efforts. These take the form of the Bureau's three periodicals, its ten nonperiodical series, interagency reports, and articles in the journals of professional organizations and technological associations.

This annual catalog, Publications of the National Bureau of Standards, cites te 1976 output of papers that document the results of the Bureau's current programs. The various media in which these papers appeared are as follows:

1.2. PERIODICALS

1.2.1. JOURNAL OF RESEARCH

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, and chemistry. It is published in two sections, available separately:

- **Physics and Chemistry (Section A)**

Papers of interest primarily to scientist working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year.

Editor: C. W. Beckett
Associate Editor: D. D. Wagman

- **Mathematical Sciences (Section B)**

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory ofexperiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly.

Editor: M. Newman
Associate Editor: F. W. Olver

Also published as a single journal, July-August 1977

1.2.2. DIMENSIONS/NBS

This magazine is published to inform both the technical expert and the interested layman of the latest advances in science and technology, with primary emphasis on the work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

The table of contents for each issue in 1976 are listed in Section 3.4, pages 52–54. Issued monthly.

Managing Editor: Juli Kelley

1.2.3. JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA (JPCRD)

This Journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature. (See also Section 1.3, National Standard Reference Data Series.)

1.3. NONPERIODICALS

Ten categories of nonperiodical publications, described as follows, are listed in this catalog:

MONOGRAPHS—major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

HANDBOOKS—recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

SPECIAL PUBLICATIONS—include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Special subject-matter subseries include Semiconductor Measurement Technology (SP400-), Standard Reference Materials (SP260-), Precision Measurement and Calibration (SP300-), Law Enforcement Technology (SP480-), and Computer Science and Technology (SP500-).

APPLIED MATHEMATICS SERIES—mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

NATIONAL STANDARD REFERENCE DATA SERIES—provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS. Program under authority of National Standard Data Act (Public Law 90-396). See also Section 1.2.3.

BUILDING SCIENCE SERIES—disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

TECHNICAL NOTES—studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Special subject-matter subseries include Optical Radiation Measurements (TN594-) and Self Calibrations Manual for Optical Radiation (TN910-).

VOLUNTARY PRODUCT STANDARDS—developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program as a supplement to the activities of the private sector standardizing organizations.

FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS (FIPS PUBS)—publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

Public distribution of FIPS PUBS is by purchase from the National Technical Information Service, Springfield, VA 22161.

CONSUMER INFORMATION SERIES—practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

1.4. NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service (Springfield, VA 22161) in paper copy or microfiche form. (See pages 7 to 32 for price lists.)

1.5. GRANTEE/CONTRACTOR REPORTS AND PATENTS

Grantee/contractor reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those contract reports not incorporated into the formal NBS publication series are available directly from the National Technical Information Service (NTIS), Springfield, VA 22161, in paper copy or microfiche form unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

Patents—legal documents which fully describe inventions in return for the right for 17 years to exclude others from making, using or selling the inventions—are obtained on NBS inventions of high commercial potential, in order to establish Government ownership of the patent rights. The patents are then made available for the grant of nonexclusive licenses to all qualified applicants. A limited exclusive license may be granted under a particular patent, however, if it appears that some period of exclusivity is necessary as an incentive for the investment of risk capital. For information on licensing any of the following patents, write to the Office of the Legal Adviser, National Bureau of Standards, Washington, DC 20234. Copies of patents may be obtained from the U.S. Patent and Trademark Office, Washington, DC 20231 for 50 cents each.

1.6. NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

The Cryogenic Data Center and the Electromagnetics Division of the National Bureau of Standards, Boulder, CO have developed specialized bibliographic issuances designed to provide interested audiences with information on latest developments in certain specialized fields. These issuances, together with subscription information, are listed below:

CRYOGENIC DATA CENTER CURRENT AWARENESS SERVICE (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, $20.00; Foreign, $25.00.

LIQUEFIED NATURAL GAS. A literature survey issued quarterly. Annual subscription: $20.00.

SUPERCONDUCTING DEVICES AND MATERIALS. A literature survey issued quarterly. Annual subscription: $20.00.

Send subscription orders and remittances for the preceding bibliographic services to the National Bureau of Standards, Cryogenic Data Center (275.02), Boulder, CO 80302.

1.7. PAPERS PUBLISHED BY OTHERS

Many significant contributions by NBS authors are published in other journals. Up-to-date listings of these articles are carried regularly in each section of the Journal of Research, along with selected abstracts. A complete listing is published annually in NBS SP305, along with abstracts, key words, and author/subject indexes.

2. PURCHASE PROCEDURES AND DOCUMENT AVAILABILITY

2.1. PURCHASE PROCEDURES

The publications of the Bureau are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, at the prices listed in this publication. However, prices are subject to change without notice. You may also order through the U.S. Department of Commerce Field Office nearest you (see Appendix B for list of Field Offices of the U.S. Department of Commerce). Microfiche copies of all recent NBS publications, and paper copies and many non-periodicals, may be ordered through the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

This section includes prices lists of available publications, plus instruction on how to acquire reprints of articles by NBS authors, and how to get out-of-print material.

How To Make Remittances. Remittances for publications for which individual sales or subscription prices are shown should be mailed to Superintendent of Documents, U.S. Government

Printing Office, Washington, DC 20402, by postal money order, express money order, or check. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money order, draft on an American bank or UNESCO coupons.*

The letter symbol, publication number, full title of the publication, SD catalog number, and SD stock number MUST be given when ordering. The Superintendent of Documents allows a discount of 25 percent on orders of 100 or more copies of one publication.

Persons who make frequent purchases from the Superintendent of Documents may find a deposit account convenient. Deposits of $25 or more are accepted against which orders may be placed without making individual remittances or first obtaining quotations. Order blanks are furnished for this purpose. After the order has been processed, the order itself is returned, showing the publications supplied, explanations regarding those not sent, the amount of charge, and the balance on deposit.

No charge is made for postage on documents sent to points in the United States and its possessions. In computing foreign postage, the charge is approximately one-fourth of the current selling price of the publication. The charge is to cover the special handling required to comply with the customs and international mailing regulations.

Orders for publications purchased from the National Technical Information Service (NTIS) must be accompanied by postal money order, express money order, or check made out to the NTIS and covering total cost of the publications order. All inquiries or orders should be addressed to: National Technical Information Service, Springfield, VA 22161.

SD and NTIS order forms are included at the end of this publication for your convenience in ordering.

2.2. ANNOUNCEMENTS OF NBS PUBLICATIONS

The National Bureau of Standards and the agencies mentioned below regularly issue the following official announcements dealing with NBS publications.

DIMENSIONS/NBS. Issued monthly by the National Bureau of Standards. In addition to publishing technical news of the Bureau, this periodical announces selected new publications in an NBS series. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription, $12.50; $15.65 foreign. Single copies, $1.00 each.

NBS JOURNAL OF RESEARCH. Both Sections A and B carry a listing of all NBS publications as issued. See 2.6 for subscription information.

Monthly Catalog of United States Government Publications. Issued monthly by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription, with consolidated annual index, $45.00; $56.00 foreign.

Selected List of U.S. Government Publications. Issued monthly by the Superintendent of Documents. Each list is arranged by subject, with annotations, prices, and order form. May be obtained free from the U.S. Government Printing Office Superintendent of Documents, Mail List Section, Stop SSOM, Washington, DC 20402

Business Service Check List. Bi-weekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards publications, as well as those of other offices of the Department of Commerce. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription, $9.00; $11.25 foreign.

2.3. CATALOGS OF NBS PUBLICATIONS

Previous catalogs, plus this publication, constitute a complete list of the titles of the Bureau's publications through December 31, 1976. The catalogs are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, unless otherwise stated, or may be consulted in a library which maintains sets of National Bureau of Standards publications.

Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947. 375 pages including subject and author indexes. Brief abstracts are included for the period January 1, 1941 to June 30, 1947..... *

*Available by purchase from the National Technical Information Service, Springfield, VA 22161.

Supplement to Circular 460: Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957. 373 pages, including subject and author indexes ..... *

Miscellaneous Publication 240: Publications of the National Bureau of Standards, July 1, 1957 to June 30, 1960. First NBS Catalog to include Titles of Papers Published in Outside Journals 1950 to 1959. 391 pages, including subject and author indexes ..... *

Supplement to Miscellaneous Publication 240: Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by others, 1960 through 1965. 740 pages, including subject and author indexes ..... *

Special Publication 305: Publications of the National Bureau of Standards, published by NBS, July 1966 through December 1967; published by others, 1966–1967. 223 pages, a citation of titles and abstracts, with key words and author indexes ..... *

Supplement 1 to Special Publication 305: Publications of the National Bureau of Standards, 1968 through 1969. 497 pages, a citation of titles and abstracts, with key words and author indexes ..... *

Supplement 2 to Special Publication 305: Publications of the National Bureau of Standards, 1970. 378 pages, a citation of titles and abstracts, with key words and author indexes ..... *

Supplement 3 to Special Publication 305: Publications of the National Bureau of Standards, 1971. 342 pages, a citation of titles and abstracts, with key words and author indexes ..... *

Supplement 4 to Special Publication 305: Publications of the National Bureau of Standards, 1972. 449 pages, a citation of titles and abstracts, with key words and author indexes $4.20

Supplement 5 to Special Publication 305: Publications of the National Bureau of Standards, 1973. 349 pages, a citation of titles and abstracts, with key words and author indexes $4.15

Supplement 6 to Special Publication 305: Publications of the National Bureau of Standards, 1974. 523 pages, a citation of titles and abstracts, with key words and author indexes $6.80

Supplement 7 to Special Publication 305: Publications of the National Bureau of Standards, 1975. 595 pages, a citation of titles and abstracts, with key words and author indexes $7.55

Supplement 8 to Special Publication 305: Publications of the National Bureau of Standards, 1976. 728 pages, a citation of titles and abstracts, with key words and author indexes $8.25

*Available by purchase from the National Technical Information Service, Springfield, VA 22161.

2.4. FUNCTIONS OF DEPOSITORY LIBRARIES IN THE UNITED STATES

The Superintendent of Documents, United States Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries.

Under provisions of Title 44 of the United States Code, certain libraries are designated depositories for Government publications. Through them Federal Government documents are made available to residents of every State, District of Columbia, Guam, Puerto Rico, and the Virgin Islands. Distribution to the libraries is made by the Office of the Superintendent of Documents.

It is sometimes impossible to obtain desired publications by purchase from the Superintendent of Documents. Stocks may have been exhausted or the document may be permanently out of print. In these instances the depositories render an invaluable service by keeping such publications permanently available. Every Government publication cannot be consulted at all depository libraries. Designated Regional Depositories are required to receive and retain one copy of all Government publications made available to depository libraries either in printed or microfacsimile form. All other libraries are allowed to select the classes of publications best suited to the interest of their particular clientele.

The libraries listed in Appendix A are now receiving selected publication series of the National Bureau of Standards for general reference use. Whether a given library has a copy of a particular publication can be determined by inquiring at the library.

2.5. FUNCTIONS OF U.S. DEPARTMENT OF COMMERCE DISTRICT OFFICES

Department of Commerce District Offices are maintained in the cities listed in Appendix B. Their purpose is to provide ready access, at the local level, to the services of the Department of Commerce as well as to its reports, publications, statistical statements, and surveys. Each District Office serves as an official sales agent of the Superintendent of Documents, U.S. Government Printing Office, making available for purchase locally a wide range of Government publications. The reference library maintained by each District Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

2.6. AVAILABILITY OF NBS PUBLICATIONS

A. PERIODICAL SUBSCRIPTION RATES

Periodical	Domestic[1]	Foreign[2]
Journal of Research of the National Bureau of Standards:		
Effective July 1977 issued bimonthly as single section. Separate Sections A and B discontinued with the June 1977 issues.		
Paper covers	$17.00	$21.25
Bound volume (1 volume per year), blue buckram	([3])	([3])
DIMENSIONS/NBS, 12 monthly issues	12.50	15.65

NOTE.—Send order, with remittance, to Superintendent of Documents, U.S. Government Priting Office, Washington, D.C. 20402.

[1]United States and its possessions.

[2]Foreign price includes the cost of the publication and postage.

[3]Prices of the bound volumes vary. The Superintendent of Documents will furnish prices on request.

B. PRICE LISTS FOR NONPERIODICALS

The following lists give the numbers and prices of all NBS publications issued from 1901 through 1976 which are still in print. Those items in **boldface** denote the 1976 publications cited in this supplement. The prices shown herein supersede prices quoted in previous catalogs of NBS publications. The prices shown are those in effect as of the date this publication went to press. Prices are subject to change without notice, and the prices that will be charged on your order will be those in effect as of the date your order is processed. Except for the Federal Information Processing Standards Series which are only available by purchase from the National Technical Information Service, Springfield, VA 22161, publications may be ordered from the Superintendent of Documents, U.S. Government Printing Office or from the U.S. Department of Commerce District Office nearest you. SD order forms are included at the end of this publication. Some NBS publications may be purchased from the National Technical Information Service. (See Section 2.1.)

For availability and price of Patents see page 3.

Publications not listed are out of print. In such cases, your nearest depository library may still have a copy of that item. (See Section 2.4 and Appendix A.)

PRICE LISTS
NBS PUBLICATIONS
CIRCULARS

No.	Price
74 (PB264-261)	**
402	.35
410	*
438	*
440 & Suppl. (PB262-014)	**
447 (PB258-782)	**
453 (PB192-338)	**
460 (PB259-278)	**
460 Suppl. (PB259-279)	**
470 (COM75-10206)	**
488 Sec. 1 & 2 (PB252-093)	**
488 Sec. 3, 4 & 5 (PB252-094)	**
499	*
510 (PB192-399)	**
510 Suppl. 1 (PB192-340)	**
510 Suppl. 2 (PB192-341)	**
524 (PB259-780)	**
536	.55
539 Vol. 1 to 10 are (PB178-902 to PB178-911)	**
245 (PB188-806)	**
556 COM73-50843)	**
564	*
571 (PB175-659)	**
576	*
577 & Suppl.	*
579 (PB168-350)	**
582 (COM75-10277)	**
589 (PB188-296)	**
593 (COM75-10234)	**
596 (PB172-059)	**
602 (COM73-10504)	**

* See page 33 for additional information.

** Available from the National Technical Information Service; use "PB", "COM" or NBS publication identification if no specific NTIS number is assigned.

MONOGRAPHS

No.	Price
2 (PB187-752)	*
3 Vol. 1 (COM71-01000-1)	*
3 Vol. 2 (COM71-01000-2)	*
4 (PB174-987)	*
7 (COM73-10503)	*
8 (PB186-237)	*
10 (COM75-10235)	*
13 (PB172-156)	*
15 (PB192-874)	*
20 (PB195-221)	*
23 (PB183-992)	*
25 Sec. 1 (PB178-429)	*
25 Sec. 2 (PB178-430)	*
25 Sec. 3 (PB178-431)	*
25 Sec. 4	*
25 Sec. 5	*
25 Sec. 6	*
25 Sec. 7	*
25 Sec. 8 (PB194-872)	*
25 Sec. 9 (COM72-50002)	*
25 Sec. 10 (COM72-51079)	*
25 Sec. 11 (SN003-003-01234-3)	1.55
25 Sec. 12 (SN003-003-01376-5)	1.50
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54 (SN003-003-01307-2)	1.25
55 (COM74-51188)	*
56 (SN003-003-01335-8)	2.35
57 (SN003-003-01364-1)	1.20
58 (SN003-003-01349-8)	2.00
59 (SN003-003-01392-7)	1.30
60 (SN003-003-01352-8)	1.05
61 (COM75-10473)	*
63 (SN003-003-01407-9)	.70
64 (SN003-003-01360-9)	1.35
65 (SN003-003-01394-3)	1.00
66 (SN003-003-01417-6)	2.10
67 (SN003-003-01468-1)	1.20
68 (SN003-003-01419-2)	1.25
69 (SN003-003-01622-5)	4.60
70 (SN003-003-	
71 (SN003-003-01459-1)	2.25
72 (SN003-003-01474-5)	1.80
73 (SN003-003-01479-6)	1.25
74 (SN003-003-01477-0)	1.55
75	*
76 (SN003-003-01644-6)	1.45
77 (SN003-003-01539-3)	2.35
78 (SN003-003-01537-7)	1.25
79 (SN003-003-01546-6)	1.15
80 (SN003-003-02183-1)	1.15
81 (SN003-003-01591-1)	.45
82 (SN003-003-02185-7)	.50
83 (SN003-003-01592-0)	.55
84	
85 (SN003-003-01619-5)	2.25
86 (SN003-003-01637-3)	1.05
87 (SN003-003-01642-0)	4.40
88 (SN003-003-01693-4)	.65
89 (SN003-003-01706-0)	.75
90 (PB257-581)	*
91 (SN003-003-01690-0)	1.40
92 (SN003-003-01692-6)	.70
95	

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BUILDING MATERIALS AND STRUCTURES REPORTS

No.	Price
2 (COM73-10942)	*
5 (COM73-10943)	*
7 (COM73-10944)	*
17 Suppl. 1 & 2, see Mono 77 (PB180646)	*
19 see BMS116	OP
21 (COM73-10945)	*
23 (COM73-10946)	*
24 (COM73-10947)	*
32 (COM73-10948)	*
41 (COM73-10949)	*
45 (COM73-10961)	*
52 (COM74-50537)	*
54 (COM73-10963)	*
55 (COM73-10964)	*
56 (COM73-10965)	*
63 (COM73-10966)	*
64 (PB177986)	*
65 (COM73-10967)	*
66	.80
71 (COM73-10968)	*
76 (COM73-10969)	*
78 (COM73-10970)	*
79 (COM73-10971)	*
81 (COM73-10972)	*
82 (COM73-10973)	*
92 (COM73-10974)	*
93 (COM73-10975)	*
94 (COM73-10978)	*
96 (COM73-10979)	*
100 (COM73-10980)	*
101 (COM73-10981)	*
103 (COM73-10982)	*
104 (COM73-10983)	*
106 (COM73-10984)	*
108 (COM73-10985)	*
109 (COM73-10986)	*
114 (COM73-10987)	*
115 (COM73-10988)	*
117 (COM73-11015)	*
118 (COM73-11014)	*
119 (COM73-11016)	*
120 (COM73-11054)	*
123 (COM73-11050)	*
124 (COM73-11051)	*
126 (COM73-11052)	*
132 (COM73-11053)	*
133 (COM73-11055)	*
134 (COM73-11056)	*
135 (COM73-11057)	*
136 (COM73-11058)	*
138 (COM73-11059)	*
141 (COM73-11060)	*
142 (COM73-11062)	*
143 (COM73-11061)	*
144 (PB180647)	*
146 (COM73-11063)	*
147 (COM73-11064)	*
149 (COM73-11065)	*
150 (COM73-11066)	*
151 (PB177987)	*

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VOLUNTARY PRODUCT STANDARDS

No.	Price
1-74 (SN003-003-01387-1)	.85
14-69	.25
15-69 (SN003-003-00188-1)	.40
20-70 (SN003-003-00192-9)	.40
26-70	.25
38-70 (SN003-003-00842-7)	.45
39-70 (SN003-003-00840-1)	.65
42-70 (SN003-003-00901-6)	.65
46-71 (SN003-003-00936-9)	.35
48-71 (SN003-003-00925-3)	.35
50-71 (SN003-003-00877-0)	.35
51-71 (SN003-003-00963-6)	.35
52-71 (SN003-003-00990-3)	.35
57-73 (SN003-003-01182-7)	.40
58-73 (SN003-003-01295-5)	.40
59-73 (SN003-003-01255-6)	.45
60-73 (SN003-003-01248-3)	.40
61-74 (SN003-003-01421-4)	.45
62-74 (SN003-003-01375-7)	.55
63-75 (SN003-003-01415-0)	.50
64-75 (SN003-003-01583-1)	.35
65-75 (SN003-003-01585-7)	.35
66-75 (SN003-003-01655-1)	.45
67-	

FEDERAL INFORMATION PROCESSING STANDARDS SERIES

No.	Price	No.	Price	No.	Price
0	3.50	16	3.50	31	5.00
1	3.50	17	3.50	32	5.00
2	3.50	18	3.50	33	4.00
3-1	3.50	19	3.50	34	3.50
4	3.50	20	3.50	35	4.00
5-1	3.50			36	3.50
6-2	4.00	21-1	13.50	37	3.50
7	3.50	22	3.50	38	4.50
8-4	3.50	23	3.50	39	3.50
9	3.50	24	4.00	40	4.50
10-2	4.00	25	3.50	41	3.50
11	6.00			42	3.50
12-2	7.50	26	3.50	43	4.50
13	3.50	27	3.50	44	3.50
14	3.50	28	3.50	45	4.00
15	3.50	29	3.50	46	3.50
		30	3.50		

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APPLIED MATHEMATICS SERIES

No.	Price	No.	Price	No.	Price
1 See AMS25	*	23 (PB175-967)	*	45 (COM74-10639)	*
2 (PB194-385)	*	24 (PB175-816)	*	46 (PB186-429)	*
3 (PB251-959)	*	25	*	47 (PB251-902)	*
4 (PB251-962)	*	26 (PB178-415)	*	48 (PB176-119)	*
5 (COM73-10501)	*	27 (AD694-116)	*	49 (PB251-903)	*
6 (PB251-862)	*	28 (AD695-952)	*	50 (PB176-520)	*
7 (PB251-863)	*	29 (AD695-953)	*	51 (PB248-467)	*
8 (PB251-864)	*	30 (PB175-817)	*	52 (PB251-904)	*
9 (COM73-10498)	*	31 (COM74-11112)	*	53 (PB186-430)	*
10 (PB251-960)	*	32 (COM73-10499)	*	54 (COM73-11111)	*
11 (AD702-411)	*	33 (PB175-818)	*	55 (SN003-003-00279-8)	12.65
12 (PB184-887)	*	34 (SN003-003-00272-1)	4.70	56 (PB190-608)	*
13 (PB251-865)	*	35 (PB251-103)	*	57 (PB266-263)	*
14 (SN003-003-00270-4)	11.70	36 (PB251-871)	*	58 (AD700-470)	*
15 (PB251-866)	*	37 (PB251-872)	*	59 (SN003-003-00282-8)	6.80
16 (PB251-867)	*	38 (PB251-900)	*	60 (SN003-003-00283-6)	1.45
17 (PB251-868)	*	39 (PB251-901)	*	61 (PB188-790)	*
18 (PB175-819)	*	40 (PB186-428)	*	62 (SN003-003-00993-8)	1.20
19 (PB175-815)	*	41 (PB176-521)	*	63 (SN003-003-00988-1)	3.45
20 (PB251-870)	*	42 (PB175-819)	*		
21 (PB178-392)	*	43 (PB176-127)	*		
22 (PB192-337)	*	44 (AD698-954)	*		

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CONSUMER INFORMATION SERIES

No.	Price	No.	Price	No.	Price
1 (SN003-003-00680-7)	.90	4 (SN003-003-00920-2)	1.10	7 (SN003-003-01688-8)	.35
2 (SN003-003-00681-5)	.90	5 (SN003-003-00941-5)	.70	8 (SN003-003-01446-0)	.70
3 (SN003-003-00682-3)	.60	6 (SN003-003-01536-9)	1.70		

TECHNICAL NOTES

No.	Price	No.	Price	No.	Price
1 (PB151-360)	*	18-19 (PB195-218)	*	40-9 (PB189-933)	*
2 (PB151-361)	*	18-20 (PB168-044)	*	40-10 (PB189-934)	*
2-2 (PB151-361-2)	*	18-21 (PB195-219)	*	40-11 (PB189-935)	*
3 (PB151-362)	*	18-22 (N661-3994)	*	40-12 (PB189-936)	*
4 (PB151-363)	*	18-23 (COM74-10437)	*	40-13 (PB151-399-13)	*
5 (PB151-364)	*	18-24 (COM74-10438)	*	41 (PB151-400)	*
6 (PB151-365)	*	18-25 (COM74-10473)	*	42 (PB151-401)	*
7 (PB151-366)	*	18-26 (COM74-10439)	*	43 (PB151-402)	*
8 (PB151-367)	*	19 (PB151-378)	*	44 (PB151-403)	*
9 (PB151-368)	*	20 (PB151-379)	*	45 (PB151-404)	*
10 (PB151-369)	*	21 (PB151-380)	*	46 (PB151-405)	*
11 (PB151-370)	*	22 (PB151-381)	*	47 (PB151-406)	*
12 (PB151-371)	*	23 (PB151-382)	*	48 (PB151-407)	*
13 (PB151-372)	*	24 (PB151-383)	*	49 (PB151-408)	*
14 (PB151-373)	*	25 (PB151-384)	*	50 (PB151-409)	*
15 (PB151-374)	*	26 (PB151-385)	*	51 (PB161-552)	*
16 (PB151-375)	*	27 (PB151-386)	*	52 (PB161-553)	*
18 (PB151-377)	*	28 (PB151-388)	*	53 (PB161-554)	*
18-2 (PB151-377-2)	*	29 (PB151-388)	*	54 (PB161-555)	*
18-3 (PB151-377-3)	*	30 (PB151-389)	*	55 (PB161-556)	*
18-4 (PB151-377-4)	*	31 (PB151-390)	*	56 (PB161-557)	*
18-5 (PB151-377-5)	*	33 (PB151-392)	*	57 (PB161-558)	*
18-6 (PB151-377-6)	*	34 (PB151-393)	*	58 (PB161-559)	*
18-7 (PB151-377-7)	*	35 (PB151-394)	*	59 (PB161-560)	*
18-8 (PB151-377-8)	*	37 (PB151-396)	*	60 (PB161-561)	*
18-9 (PB151-377-9)	*	38 (PB151-397)	*	61 (PB161-562)	*
18-10 (PB151-377-10)	*	39 (PB151-398)	*	62 (PB161-563)	*
18-11 (PB151-377-11)	*	40-1 (PB151-399-1)	*	63 (PB161-564)	*
18-12 (PB151-377-12)	*	40-2 (PB151-399-2)	*	64 (PB161-565)	*
18-13 (PB151-377-13)	*	40-3 (PB151-399-3)	*	66 (PB161-567)	*
18-14 (PB195-273)	*	40-4 (PB151-399-4)	*	67 (PB161-568)	*
18-15 (PB195-215)	*	40-5 (PB151-399-5)	*	68 (PB161-569)	*
18-16 (PB195-216)	*	40-6 (PB151-399-6)	*	69 (PB161-570)	*
18-17 (PB195-217)	*	40-7 (PB151-399-7)	*	70 (PB161-571)	*
18-18 (PB168-058)	*	40-8 (PB189-932)	*	71 (PB161-572)	*

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No.	Price	No.	Price	No.	Price
72 (PB161 573)	*	120A (PB190-611)	*	196 (COM73-10483)	*
73 (PB161-574)	*	121 (PB161-622)	*	197 (AD419-866)	*
74 (PB161-575)	*	122 (PB161-623)	*	199 (AD683-408)	*
75 (PB161-576)	*	123 (PB161-624)	*	200 (N64-14272)	*
76 (PB161-577)	*	124 (PB161-625)	*	201 (PB182-539)	*
77 (PB161-578)	*	125 (PB161-626)	*	202	*
78 (PB161-579)	*	128 (PB161-629)	*	204 (PB184-118)	*
79 (PB161-580)	*	129 (PB161-630)	*	205 (COM73-10634)	*
80 (PB161-581)	*	129A	*	206-1 (COM73-10684)	*
81 (PB161-582)	*	130 (PB161-631)	*	206-2 (COM73-10685)	*
82 (PB161-583)	*	131 (PB161-632)	*	206-3 (COM73-10686)	*
83 (PB161-584)	*	132 (PB161-633)	*	206-4 (COM73-10687)	*
84 (PB161-585)	*	133 (PB161-634)	*	206-5 (COM73-10688)	*
85 (PB161-586)	*	134 (PB161-635)	*	207 (COM73-10689)	*
86 (PB161-587)	*	135 (PB161-636)	*	209 (PB168-043)	*
87 (PB161-588)	*	136 (PB161-637)	*	210 (PB189-930)	*
88 (PB161-589)	*	137 (PB161-638)	*	211	*
89 (PB161-590)	*	138 (PB161-639)	*	214 (PB189-931)	*
90 (PB161-591)	*	139 (PB161-640)	*	215 (PB188-808)	*
91 (PB161-592)	*	140 (PB161-641)	*	217 (PB189-103)	*
92 (PB161-593)	*	141 (PB161-729)	*	218 (PB188-809)	*
93 (PB161-594)	*	142 (PB161-643)	*	219 (PB186-279)	*
94 (PB161-595)	*	143 (PB161-644)	*	220 (COM74-11077)	*
95 (PB151-596)	*	146 (PB161-647)	*	221 (COM71-00690)	*
96 (PB161-597)	*	147 (PB161-648)	*	223 (PB168-051)	*
97 (PB161-598)	*	148 (PB161-649)	*	224 (PB184-119)	*
98 (PB186-280)	*	151 (PB191-730)	*	225 (AD614-056)	*
99 (PB186-431)	*	154 (PB172-217)	*	226 (PB168-042)	*
100 (COM74-10393)	*	154A PB182-435)	*	227 (PB184-473)	*
100-A	*	160	*	228 (PB191-731)	*
101-1 (AD687-820)	*	163 (COM71-01002)	*	229 (PB188-805)	*
101-2 (AD687-821)	*	164 (N-6314864)	*	231 (COM72-10587)	*
102 (PB161-603)	*	165 (AD401-044)	*	233 (COM75-10054)	*
106 (PB161-607)	*	166 (PB181-454)	*	234 (COM73-10485)	*
107 (PB161-608)	*	171		235 (COM73-10481)	*
108 (PB161-609)	*	172 (PB193-915)	*	236 (AD437-308)	*
109 (PB161-610)	*	173 (COM75-10523)	*	237 (COM75-10166)	*
110 (PB161-611)	*	174 (COM72-10376)	*	245 (PB184-177)	*
111 (PB161-612)	*	177 (COM72-10514)	*	249 (PB168-046)	*
112 (PB161-613)	*	178 (PB190-917)	*	252 (AD612-812)	*
113 (PB161-614)	*	179 (PB190-610)	*	253 (PB184-176)	*
114 (PB161-615)	*	180 (COM75-10083)	*	255 (AD614-257)	*
115 (PB161-616)	*	182 (COM75-10283)	*	260 (PB168-041)	*
116 (PB616-617)	*	183 (COM75-10052)	*	261	**
117 (PB161-618)	*	187 (PB188-807)	*	262-A (COM73-10486)	*
118 (PB161-619)	*	191 (PB182-538)	*	263 (COM75-10486)	*
119 (PB161-620)	*	194 See NSRDS1	.55	266 (PB195-214)	*
120 (PB161-621)	*	195 (COM73-10418)	*	267 (AD628-586)	*

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No.	Price
268	*
270-1 See TN270-3	3.25
270-2 See TN270-3	3.25
270-3 (SN003-003-00406-5)	3.25
270-4 (SN003-003-00407-3)	2.10
270-5 (SN003-003-00811-4)	Exh.
270-6 (SN003-003-00932-6)	1.90
270-7 (SN003-003-01139-8)	1.25
270-8	
273 (PB248-534)	*
275 (COM73-10484)	*
277	*
278	*
279 (COM75-10375)	*
280 (COM72-10590)	*
285 (AD633-354)	*
287 (PB182-436)	*
288	*
291	*
292 (COM75-10335)	*
293 (COM75-10335)	*
294 (PB176-289)	*
295	*
297 (PB188-657)	*
298 (PB186-238)	*
300 (PB168-048)	*
303 (AD611-400)	*
304 (AD615-936)	*
307 (PB168-040)	*
309 (N-65-24999)	*
310 (AD615-937)	*
318 (COM75-10374)	*
319	*
321 (COM75-10238)	*
322 (COM75-10236)	*
323 (COM75-10237)	*
324 (AD654-887)	*
331	*
332	*
334 (PB173-291)	*
337	**
341	*
343	*
345	*
346 (PB194-282)	*
347	*
349	*
355	*
360 (PB190-125)	*
361 (COM75-50052)	*
361 (SN003-003-01321-8) (Metric Version)	1.25
362 (COM74-10482)	*
363	*
364	*
365	*
365-1 (COM71-00048)	*
366	*
367	*
368	*
370 (AD688-697)	*
372	*
373	*
374	*
375	*
377	*
378	*
379 (SN003-003-00834-6)	.65
381	*
382	*
383	*
384 (COM75-10174)	*
385 (PB190-548)	*
386 (PB191-638)	*
387 (COM74-50059)	*
388 (COM71-50077)	*
389	*
390 (PB191-639)	*
391	*
393 (COM75-10043)	*
397 (COM71-50060)	*
398 (SN003-003-00814-1)	.40
399 (COM71-50294)	*
400	*
403	*
406	*
409	*
410	*
411	*
412	*
414 (PB176-109)	*
416	*
417	*
419 (PB179-432)	*
420	*
421	*
423	*
425	*
426	*
428	*
431	*
432	*
434	*
435	*
436	*
437	*
438 (AD665-245)	*
439	*
440	*
444	*
445	*
461	*
464	*
465	
467 (COM72-50871)	*
469	*
470	*
472 (AD681-330)	*
473	*
474 (AD681-351)	*
475 (AD683-808)	*
476	*
477	*
478 (PB190-609)	*
479	*
480	*
483	*
484 (AD692-231)	*
485	*
486	*
487	*
488 (AD692-232)	*
490	*
491	*
493 withdrawn	
495 (AD695-820)	*
496	*

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No.	Price
497 (AD695-821)	*
498 (SN003-003-00590-8)	.65
498-1 (SN003-003-00774-9)	.60
498-2 (SN003-003-00686-6)	.70
500 (PB191-352)	*
503	*
510	*
511	*
513 (AD702-871)	*
515 (SN003-003-00606-8)	.65
517	*
519 (PB190-760)	*
520 (AD702-833)	*
521 See TN719	OP
522 (PB191-024)	*
523 (PB191-057)	*
524 (PB191-277)	*
525	1.10
527 (AD710-906)	*
528 (PB191-305)	4.50
529 (PB192-153)	*
530 (COM71-00047)	*
532 (SN003-003-00776-5)	.75
533 (PB192-875)	*
534 (PB192-877)	*
536 (PB192-953)	*
543 (COM71-00081)	*
544 (PB194-960)	*
547 (COM71-00082)	*
550 (COM71-00068)	*
551 (COM71-50076)	*
552 (SN003-003-00918-1)	3.25
554	2.20
555 (AD718-534)	*
557 (COM74-10405)	*
558 (COM71-50072)	*
560 (AD719-976)	*
562 (COM71-00128)	*
563 (COM71-50341)	*
566 (COM71-50062)	*
568 (AD728-642)	*
569 (COM74-10436)	*
570 (COM71-50075)	*
572 (COM71-50150)	*
573 (COM71-50227)	*
575 (COM75-10280)	*
577 (COM71-50264)	*
578 (COM75-10185)	*
579 (COM75-10184)	*
584 (COM71-50635)	*
585 (COM71-50066)	*
588 unassigned	
589 (COM71-50061)	*
590 (COM71-50292)	*
591 (COM75-10168)	*
592 (SN003-003-00892-3)	1.15
593 (COM72-50031)	*
594-1 (COM72-50674)	*
594-2 (COM72-51003)	*
594-3 (COM75-10183)	*
594-4 (COM73-50224)	*
594-5 (SN003-003-00159-7)	.55
594-6 (SN003-003-01253-0)	.95
01244-1)	.75
594-7 (SN003-003-	
594-8 (SN003-003-01285-8)	.95
594-9 (SN003-003-01342-1)	1.10
594-10 (SN003-003-01453-2)	.85
594-11 (SN003-003-01675-6)	1.15
594-12 (SN003-003-01676-4)	.75
595 (COM71-50362)	*
596 (SN003-003-00904-1)	1.05
597 (COM75-10176)	*
598 (AD732-553)	*
599 (COM71-50399)	*
600 (COM71-50297)	*
602 (SN003-003-00880-0)	.55
604 (SN003-003-00861-3)	.65
606 (COM71-50325)	*
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74-473 (COM74-11719)	4.50
74-474 (AD778340)	4.00
74-477 (COM74-11784)	4.00
74-479 (PB239420)	6.00
74-481 (COM74-11794)	4.50
74-482 (COM75-10147)	7.75
74-485 (AD780-704)	3.50
74-486 (AD780-705)	4.50
74-478 (COM74-10886)	13.00
74-488 (COM75-10088)	5.50
74-493 (PB243-545)	3.50
74-495 (COM74-11575)	5.00
74-496 (COM74-11576)	5.00
74-497 (COM74-11269)	3.50
74-499 (COM74-11378)	4.00
74-501 (COM75-10131)	3.50
74-506 (COM74-11632)	5.00
74-507 (AD/A0001343)	4.00
74-509 (COM74-11377)	3.50
74-510 (AD782-793)	4.00
74-511 (COM74-11448)	3.50
74-514 (COM75-10102)	4.50
74-515 (COM74-11498)	7.50
74-516 (COM74-11384)	4.50
74-518 (PB239-633)	5.00
74-520 (COM74-11480)	6.00
74-519 (PB238284)	4.00
74-521 (COM75-10187)	4.50
74-522 (COM75-10080)	3.50
74-523 (COM75-11126)	3.50
74-524 (COM74-11568)	4.00
74-525 (AD782-564)	3.50
74-526 (COM75-10087)	4.50
74-527 (COM74-11720)	4.50
74-529 (COM74-11495)	4.50
74-530 (COM75-10041)	4.00
74-533 (PB238-573)	5.50
74-535 (COM74-11659)	5.00
74-537 (COM74-11577)	3.50
74-539 (COM74-11574)	5.00
74-541 (COM75-10618)	4.00
74-542 (COM75-10081)	4.00
74-543 (COM74-11772)	6.00
74-544 (COM74-11525)	4.00
74-545 (COM74-11656)	4.50
74-550 (COM74-11721)	5.00
74-551 (COM74-11658)	5.50
74-552 (COM74-11644)	5.00
74-553 (COM75-10058)	4.50
74-554 (COM74-10703)	3.50
74-555 (COM74-10704)	4.00
74-556 (COM74-10703)	5.00
74-557 (COM75-11439)	4.00
74-561 (COM75-10413)	4.00
74-564 (COM74-11726)	4.50
74-567 (COM74-11631)	9.25
74-568 (COM74-11578)	4.50
74-569 (AD/A002-289)	4.00
74-572 (COM74-11791)	4.50
74-577-1 (COM74-11723)	7.50
74-577-2 (COM74-11724)	9.75
74-578 (COM74-11765)	3.50
74-580 (PB248-465)	3.50
74-581 (COM75-10127)	4.00
74-582 (COM74-11645)	4.00
74-583 (AD/A003-900)	5.00
74-586 (COM75-10525)	3.50
74-588 (COM75-10040)	4.00
74-590 (COM75-11434)	3.50
74-594 (PB243-546)	3.50
74-591 (COM75-10101)	3.50
74-595 (COM75-10057)	3.50

No.	Price	No.	Price
74-596 (COM75-10209)	4.00	75-677 (COM75-10516)	4.50
74-597 (COM75-11069)	4.00	75-678 **(PB248-687)**	**4.50**
74-600 (AD/A008-935)	7.50	75-679 (COM75-10419)	4.00
74-602 (COM75-10048)	4.00	75-680 (COM75-10423)	5.50
74-605 (COM75-10464)	4.00	75-682 (COM75-10524)	3.50
74-606 (COM75-10340)	5.00	75-685 (COM75-10690)	5.00
74-608 (COM75-10056)	3.50	75-687 (COM75-11137)	6.00
74-610 (COM75-10073)	4.00	75-688 (COM75-11222)	5.50
74-612 (COM75-10414)	3.50	75-689 (COM75-11190)	4.50
74-613 (COM75-10059)	4.00	75-690 (COM75-11207)	5.00
74-614 (COM75-11013)	4.00	75-691 (COM75-11015)	5.00
74-618 (COM75-11014)	3.50	75-692 (PB250-385)	5.50
74-619 (COM75-10047)	3.50	75-693 (COM75-11194)	3.50
74-620 (PB246-622)	3.50	75-696 (COM75-10527)	5.00
74-621 (COM75-10422)	4.00	75-697 (COM75-10920)	4.50
74-623 (COM75-10210)	5.00	75-699 (COM75-11016)	4.00
74-624 (COM75-10412)	4.00	75-700 (COM75-11280)	4.50
74-625 **(PB243-547)**	**4.00**	75-701 (COM75-11282)	3.50
74-626 (COM75-10411)	3.50	75-702 (COM75-11433)	4.00
74-627 (COM75-10134)	3.50	75-703 (COM75-11278)	4.00
74-628 (COM75-10514)	3.50	75-705 (COM75-11277)	4.00
74-629 (COM75-11281)	4.00	75-706 (PB248-640)	3.50
74-631 (COM75-10208)	3.50	75-707 (COM75-11017)	4.00
74-632 (PB246-554)	5.00	75-708 (COM75-10817)	3.50
74-633 (COM75-10691)	4.50	75-710 (COM75-11030)	3.50
74-634 (COM75-10685)	4.00	75-711 (COM75-10689)	4.50
74-635 (COM75-10276)	4.50	75-712 (COM75-11070)	4.00
75-637 (COM75-10055)	3.50	75-713 (COM75-11134)	4.50
75-638 (AD/A011-485)	4.50	75-715 (COM75-11208)	3.25
75-639 (AD/A005-410)	3.50	75-716 (COM75-11210)	6.25
75-641 (COM75-11209)	5.00	75-718 (COM75-10750)	3.25
75-647 (COM75-10418)	4.00	75-719 **(PB251-410)**	**3.50**
75-649 (PB241-237)	3.50	75-721 (PB246-864)	4.00
75-651 (COM75-11211)	5.00	75-722 **(PB248-641)**	**4.00**
75-652 (COM75-11399)	5.00	75-723 (COM75-10753)	4.75
75-653 (PB248-097)	4.00	75-728 (AD/A014-830)	4.00
75-654 (COM75-10367)	3.50	75-729 (PB246-858)	4.00
75-658 (AD/A007-445)	4.00	75-730 (AD/A018451)	3.75
75-659 (AD/A008-538)	4.00	75-731 (COM75-11071)	3.75
75-660 (COM75-10669)	4.00	75-732 (COM75-11022)	3.25
75-661 (COM75-10763)	4.00	75-733 (COM75-11139)	3.25
75-662 (COM75-10420)	3.50	75-734 (COM75-11212)	4.25
75-664 (AD/A007-447)	4.00	75-735 **(PB256-295)**	**6.00**
75-665 (COM75-10421)	4.00	75-736 (COM75-11018)	3.50
75-666 (COM75-11381)	4.00	75-737 (COM75-11472)	4.00
75-667 **(PB241-267)**	**4.00**	75-738 (COM75-11279)	4.00
75-672 (COM75-10338)	4.00	75-739 (COM75-11189)	3.50
75-673 (COM75-10921)	4.00	75-740 (COM75-11127)	4.00
75-675 (COM75-10686)	3.50	75-741 (COM75-11136)	4.00
75-676 (COM75-10697)	5.00	75-742 **(PB248-744)**	**4.50**

No.	Price	No.	Price
75-744 (COM75-11072)	3.50	75-820 (PB246436)	4.50
75-745 (PB347-657)	4.00	75-822 (PB246933)	4.00
75-746 (COM75-11432)	4.50	75-823 (PB246658)	5.00
75-747 (COM75-11131)	4.00	75-825 (PB258-913)	4.50
75-748 (COM75-11031)	5.00	75-827 (PB247-938)	3.50
75-750 (PB249-934)	4.00	75-828 (PB249-041)	7.50
75-571 (AD/A017626)	4.00	75-829 (PB248-855)	4.00
75-752 (PB245-013)	5.00	75-900 (PB250-859)	4.00
75-754 (N75-31909)	5.00	75-901 (PB246-860)	4.00
75-755 (PB248-642)	4.00	75-902 (PB249-539)	4.00
75-757 (PB248-914)	4.00	75-903 (PB246859)	4.00
75-760 (AD/A016-843)	7.75	75-908 (PB247-270)	3.50
75-761 (COM75-11377)	5.50	75-909 (PB246-863)	3.50
75-763 (COM75-11276)	7.75	75-910 (PB248-646)	5.50
75-766 (COM75-11376)	4.50	75-913 (PB248-911)	4.00
75-767 (PB246-879)	4.00	75-915 (PB249-775)	3.50
75-768 (PB247-943)	4.00	75-916 (AD/A019648)	5.00
75-769 (PB246978)	8.00	75-917 (PB247-655)	3.50
75-770 (COM75-11370)	4.00	75-918 (PB251-412)	5.00
75-772 (PB246-861)	4.50	75-920 (PB248-913)	4.00
75-774 (COM75-11364)	4.50	75-923 (PB250-767)	3.50
75-775 (PB248-864)	4.50	75-924 (PB248-686)	5.00
75-778 (PB246-435)	4.50	75-926 (PB257-467)	5.50
75-799 ((PB249-935)	5.50	75-927 (PB255-809)	4.50
75-781 (AD/A015630)	3.50	75-929 (PB261-498)	4.00
75-782 (PB248-643)	4.00	75-930 (PB258-250)	4.50
75-784 (PB246-862)	4.50	75-931 (PB261-030)	4.00
75-785 (PB246-345)	3.50	75-932 (PB257-425)	4.50
75-786 (PB251-411)	4.50	75-933 (PB248-983)	4.50
75-787 (AD/A016-844)	4.50	75-937 (PB265-614)	3.50
75-788 (PB250-843)	4.00	75-942 (PB256-644)	4.50
75-790 (PB250-848)	10.50	75-943 (PB258-914)	5.00
75-791 (PB253-229)	4.50	75-944 (PB258-372)	4.00
75-793 (PB247-538)	4.50	75-947 (PB258-323)	4.50
75-794 (PB247-203)	4.00	75-950 (PB250-664)	4.00
75-795 (PB246-866)	4.50	75-951 (PB249-094)	4.00
75-796 (PB247-656)	3.50	75-952 (PB248-910)	4.00
75-797 (COM75-11465)	3.50	75-953 (PB256-219)	4.00
75-801 (PB252-044)	6.75	75-954 (PB253-242)	4.00
75-804 (COM75-10395)	4.00	75-955 (PB248-685)	6.75
75-805 (PB252-971)	4.00	75-956 (PB247-654)	3.50
75-806 (COM75-10368)	4.50	75-957 (PB250-769)	3.50
75-807 (COM75-10396)	5.00	75-958 (PB248-743)	3.50
75-809 (COM75-10989)	4.00	75-960 (PB249-774)	4.50
75-810 (COM75-10919)	5.50	75-961 (PB257-466)	8.00
75-812 (Ad/A012889)	4.00	75-962 (PB247-639)	3.50
75-814 (COM75-11132)	4.50	75-966 (PB250-768)	3.50
75-816 (AD/A001250)	4.50	75-967 (PB251-413)	3.50
75-818 (PB246439)	4.00	75-968 (PB250-845)	4.00
75-819 (PB258554)	5.50	75-971 (PB249-776)	4.00

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No.	Price
75-972 (PB259-630)	5.00
75-973 (PB249-255)	4.50
75-974 (PB249-777)	5.50
75-975 (PB253-113)	4.00
75-976 (PB248-986)	4.00
75-977 (PB251-220)	4.00
76-833 (PB250846)	4.00
76-834 (PB250-666)	4.00
76-836 (PB254-459)	4.00
76-837 (PB261-709)	6.00
76-839 (PB252-013)	6.75
76-840 (PB258-324)	4.00
76-841 (PB256-319)	4.00
76-842 (PB258-331)	3.50
76-844 (PB264-300)	4.50
76-846 (PB258-327)	4.00
76-848 (PB261-996)	9.75
76-979 (PB248-992)	3.50
76-980 (PB250-849)	7.75
76-982 (PB248-699)	10.00
76-983 (PB251-213)	4.00
76-984 (PB262-020)	6.00
76-985 (PB250-755)	4.50
76-986 (PB250-858)	4.50
76-987 (PB250-857)	3.50
76-988 (PB254-469)	5.00
76-990 (PB251-769)	3.50
76-991 (AD/A021255)	3.50
76-922 (AD/A021295)	4.50
76-993 (PB253-227)	4.00
76-996 (PB251-998)	4.00
76-997 (PB254-298)	5.00
76-998 (PB253-228)	3.50
76-1000 (PB251-219)	4.50
76-1002 (PB257-469)	4.50
76-1003 (PB251-211)	3.50
76-1007 (PB252-021)	4.50
76-1008 (PB251-218)	4.00
76-1010 (PB250-654)	4.00
76-1011 (PB259-641)	4.00
76-1012 (PB257-197)	4.50
76-1013 (PB256-130)	4.00
76-1014 (PB251-414)	3.50
76-1015 (PB249-530)	9.25
76-1016 (PB254-177)	4.50
76-1017 (PB251-917)	4.00
76-1018 (PB257-779)	4.50
76-1019 (PB251-944)	3.50
76-1020 (PB258-256)	4.00
76-1021 (PB257-101)	4.50
76-1022 (PB259-628)	3.50
76-1023 (PB256-191)	3.50
76-1024 (PB255-876)	4.50
76-1025 (PB251-753)	5.00
76-1027 (PB253-243)	4.00
76-1028 (PB251-415)	3.50
76-1029 (PB261-199)	4.00
76-1031 (PB253-932)	3.50
76-1034 (PB254-460)	5.00
76-1037 (PB253-933)	4.00
76-1038 (PB251-918)	3.50
76-1039 (PB254-047)	4.00
76-1040 (PB254-178)	3.50
76-1041 (PB257-087)	4.50
76-1043 (PB254-347)	5.50
76-1046 (PB256-476)	5.50
76-1049 (PB256-600)	4.50
76-1050 (PB253-111)	4.50
76-1052 (PB258-118)	5.00
76-1054 (PB253-110)	5.50
76-1056 (PB254-179)	4.00
76-1058 (PB262-097)	6.00
76-1059 (PB257-086)	6.75
76-1060 (PB253-934)	4.00
76-1061 (PB256-328)	4.50
76-1063 (PB257-102)	4.00
76-1064 (PB257-102)	4.50
76-1066 (PB254-473)	3.50
76-1067 (PB257-195)	4.00
76-1069 (PB256-296)	4.00
76-1070 (PB260-913)	6.00
76-1072 (PB255-446)	4.50
76-1074 (PB261-497)	4.00
76-1076 (PB254-180)	4.00
76-1081 (PB256-329)	5.00
76-1082 (PB258-235)	6.75
76-1083 (PB255-803)	5.50
76-1084 (PB257-180)	4.00
76-1087 (PB257-202)	4.00
76-1089 (PB254-475)	7.75
76-1090 (PB255-505)	4.00
76-1091 (PB257-768)	4.00
76-1093 (PB256-318)	3.50
76-1095 (PB255-808)	5.00
76-1096 (PB257-076)	4.50
76-1097 (PB257-141)	4.00
76-1098 (PB259-523)	4.00
76-1099 (PB258-612)	5.50

NBS INTERAGENCY REPORTS—Continued

No.	Price	No.	Price
76-1100 (PB258-371)	4.50	76-1138 (PB259-522)	4.50
76-1102 (PB257-729)	6.75	76-1140 (PB259-626)	11.75
76-1107 (PB258-322)	4.50	76-1141 (AD/A031530)	4.00
76-1109 (PB257-194)	4.50	76-1142 (PB263-099)	3.50
76-1110 (PB257-073)	4.00	76-1143 (PB257-769)	4.00
76-1112 (PB259-636)	4.00		
76-1115 (PB257-196)	3.50	76-1144 (PB259-243)	3.50
76-1120 (PB257-837)	3.50	76-1147 (PB259-637)	4.00
76-1124 (PB261-846)	5.00	76-1153 (PB259-638)	3.50
76-1126 (PB260-878)	4.50	76-1154 (PB260-400)	7.50
		76-1154 (PB260-401)	6.00
76-1130 (PB257-347)	7.50		
76-1131 (PB259-242)	4.00	76-1159 (PB261-994)	4.00
76-1132 (PB260-363)	5.00	76-1162 (PB260-879)	4.50
76-1133 (PB261-228)	6.75	76-1172 (PB261-217)	4.00
76-1136 (PB261-965)	4.50	76-1176 (PB261-995)	4.00
76-1137 (PB257-770)	5.00	76-1187 (PB262-114)	5.50

GRANTEE/CONTRACTOR REPORTS

No.	Price	No.	Price
73-1 (PB192-365)	4.00	74-29 (PB176-913)	4.50
73-2 (PB194-614)	5.00	74-30 (COM74-11732)	4.00
73-3 (COM71-00605)	7.75	74-31 (COM74-11733)	3.50
73-4 (COM73-10323)	4.50	74-32 (COM75010039)	4.50
73-5 (COM73-10951)	6.75	75-33 (COM75-10133)	8.00
73-6 (COM73-10959)	4.50	75-34 (COM75-10128)	4.50
73-7 (COM73-10958)	4.50	73-35 (COM75-10341)	5.00
73-8 (COM73-10954)	7.75	75-36 (PB261-144)	10.50
73-9 (COM73-10953)	4.00	75-37 (PB261-145)	5.50
73-10 (COM73-10952)	6.75	75-38 (PB261-021)	5.00
73-11 (PB242-597)	9.00	75-40 (COM75-10696)	4.00
73-12 (COM73-10955)	5.50	75-42 (COM75-10805)	13.50
73-13 (COM73-10957)	5.00	75-43 (AD-16782)	5.50
73-14 (COM73-10950)	4.50	75-44 (COM75-10991)	7.75
73-15 (PB242-582)	10.00	75-45 (PB257-835)	3.50
73-16 (COM73-11265)	4.50	75-46 (PB247-235)	7.50
73-17 (COM74-10932)	6.00	75-47 (PB247-236)	10.75
73-18 (COM73-11783)	4.00	75-48 (PB248-781)	7.50
73-19 (COM74-10481)	4.50	75-50 (PB247-939)	6.00
73-21 (COM74-10722)	6.00	75-51 (PB247-483)	10.00
74-22 (COM74-10934)	10.50	76-54 (PB251-682)	5.00
74-23 (COM74-10929)	3.00	76-55 (PB250-571)	4.50
74-24 (COM74-10983)	5.00	76-56 (PB250-572)	4.50
74-25 (COM74-11075)	6.00	76-57 (PB250-573)	5.50
74-26 (COM74-11633)	5.50	76-58 (PB256-291)	6.00
74-27 (COM75-10143)	5.50	76-59 (PB256-639)	8.00
74-28 (PB176-912)	9.00	76-60 (PB253-588)	6.75

GRANTEE/CONTRACTOR REPORTS (Continued)

No.	Price	No.	Price
76-61 (PB253-553)	5.00	76-72 (PB256-190)	5.50
76-63 (PB256-440)	5.50	76-73 (PB257-424)	6.75
76-64 (PB255-445)	5.00	76-74 (PB256-771)	4.00
76-69 (PB254-276)	5.50	76-75 (PB261-201)	4.00
76-70 (PB254-748)	4.50	76-76 (PB261-200)	5.50
76-71 (PB254-751)	4.50	76-79 (PB259-127)	4.00

EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM REPORTS

No.	Price	No.	Price
73-01 (COM73-11373)	6.25	76-09 (PB252-488)	4.00
73-02 (COM73-11375)	4.75	76-10 (PB253-260)	4.00
73-03 (COM73-11374)	4.25	76-11 (PB253-115)	5.50
73-04 (COM74-10256)	3.00	76-12 (PB254-996)	11.75
73-05 (COM74-10257)	4.50	76-13 (PB253-475)	4.00
73-06 (COM74-10258)	4.00	76-14 (PB253-476)	3.50
73-07 (COM74-10939)	5.00	76-15 (PB253-477)	4.00
73-07 (COM74-10940)	9.75	76-16 (PB256-129)	8.00
75-01 (COM75-11369)	5.75	76-17 (PB254-233)	7.75
76-03 (PB251-266)	4.50	76-18 (PB256-642)	4.00
76-04 (PB251-683)	10.00	76-19 (PB256-643)	4.00
76-05 (PB253-108)	4.00	76-22 (PB257-884)	12.00
76-06 (PB253-918)	7.50	76-23 (PB258-991)	4.00
76-08 (PB254-078)	4.00	76-24 (PB258-093)	8.00

C. SUPERSEDED NBS REFERENCE PUBLICATIONS

Those NBS publications not listed in the Price Lists are out of print and are not available from the Superintendent of Documents. Many can be consulted at libraries. Also, in many cases, photoduplicated copies can be purchased from the Library of Congress. For full information concerning this service, write to the Photoduplication Service, Library of Congress, Washington, DC 20540.

Certain NBS publications are out of print because they have been replaced, or partially replaced, by material issued by other organizations. In this connection NBS is able to offer the following information:

Circular 410, National Standard Petroleum Oil Tables. Information in this Circular has been incorporated in the ASTM-IP Petroleum Measurement Tables issued by the American Society for Testing and Materials, 1916 Race Street, Philadelphia PA 19103. Available at $12.75, 20% off to ASTM members. Tables 5 and 7 of the ASTM-IP Tables may also be purchased from the ASTM in separate reprint form at $2.25 and $2.00 per copy respectively.

Circular 438, Static Electricity. The National Fire Protection Association, 60 Batterymarch Street, Boston, MA 02110, has issued a publication by the same title, available from them as NFPA Publication 77, at $2.00.

Circular 499, Nuclear Data. Replaced by Atomic and Nuclear Data Tables, published by Academic Press, 111 Fifth Avenue, New York, NY 10003. Available by subscription for $88.00 per year.

Circular 564, Tables of Thermal Properties of Gases. A reprinted edition is available from University Microfilms, Inc., Ann Arbor, MI 48106. Order as OP 12,192 for $56.80, Microfiche of this Circular is available from Cryogenic Data Center, National Bureau of Standards, Boulder, CO 80302.

Circular 576, Automotive Antifreezes. For information on this subject consult American National Standards Institute, 1430 Broadway, New York, NY 10018.

Circular 577 and Supplement, Energy Loss and Range of Electrons and Positrons. These have been superseded by NASA Special Publication 3012, available from the National Technical Information Service, Springfield, VA 22161, at $6.75 hardcopy and $3.00 microfiche number N65-12506.

Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. The American National Standards Institute, 1430 Broadway, New York, NY 10018, has issued a publication on this subject. Available from them as A58.1-1969-1972, at $7.50.

Miscellaneous Publication 187, Directory of Commercial and College Laboratories. A new Directory of Testing Laboratories is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, at $3.75.

Miscellaneous Publication 211, American Standards Building Code Requirements for Masonry. The American National Standards Institute, 1430 Broadway, New York, NY 10018, has issued a publication on this subject. Available from them as A41.1-1953-R1970, at $4.50.

Handbook 30, National Electrical Safety Code (also H81 and its Supplements and H110-1). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2, at $6.50.

Handbook 46, Code for Protection Against Lightning. A United States of America Standards Institute Code for Protection Against Lightning (NFPA-78-1969) is available from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at $4.25, as C5.1-1969-1975.

Handbook 48, Control and Removal of Radioactive Contamination in Laboratories. Reprints of this Handbook can be purchased as NCRP Report 8 at $2.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 49, Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medi-

cal Users. Reprints of this Handbook can be purchased as NCRP Report 9 at $2.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 53, Recommendations for the Disposal of Carbon-14 Wastes. Reprints of this Handbook can be purchased as NCRP Report 12 at $2.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 55, Personal Protection for the Radiation Produced by Betatrons. Reprints of this Handbook can be purchased as NCRP Report 14 at $2.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 58, Radioactive Waste Disposal in the Ocean. Reprints of this Handbook can be purchased as NCRP Report 16 at $2.00 from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 59, Permissible Dose from External Sources of Ionizing Radiations. Reprints of this Handbook can be purchased as NCRP Report 39 at $4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 63, Protection Against Neutron Radiation up to 30 MeV. Reprints of this Handbook can be purchased as NCRP Report 38 at $5.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes. Reprints of this Handbook can be purchased as NCRP Report 37 at $4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 69, Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure. Reprints of this Handbook can be purchased at $3.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 71, Specifications for Dry Cells and Batteries. Available as C18.1-1972 from the American National Standards Institute, 1430 Broadway, New York, NY 10018, at $6.25.

Handbook 73, Protection Against Radiations from Sealed Gamma Sources (Supersedes H54). Reprints of this Handbook can be purchased as NCRP Report 40 at $4.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 74, Building Code Requirements for Reinforced Masonry. The American National Standards Institute, 1430 Broadway, New York, NY 10018 has issued a publication on this subject. Available from them as A41.2-1960 (R1970), at $3.25.

Handbook 75, Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays. Reprints of this Handbook can be purchased as NCRP Report 25 at $2.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 76, Medical X-ray Protection Up to Three Million Volts. Now NCRP 33 and 34 respectively. Purchase from NCRP Publications, Post Office Box 30175, Washington, DC 20014, at $3.00 and $4.00 respectively.

Handbook 80, A Manual of Radioactivity Procedures. Reprints of this Handbook can be purchased as NCRP Report 28 at $3.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 81 and its Supplements, Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines (also H30 and H110-1). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2, at $6.50.

Handbook 84, Radiation Quantities and Units. Reprints of this Handbook can be purchased as ICRU Report 19 at $5.00 per copy from ICRU Publications, Post Office Box 30165, Washington, DC 20014.

Handbook 89, Methods of Evaluating Radiological Equipment and Materials. Reprints of this Handbook can be purchased as ICRU Report 10F

at $2.50 per copy from ICRU Publications, Post Office Box 30165, Washington, DC 20014.

Handbook 96, Inspection of Processed Photographic Record Films for Aging Blemishes. Reprints of this Handbook can be purchased as PH 1.28–1973 at $4.00 per copy from The American National Standards Institute, 1430 Broadway, New York, NY 10018.

Handbook 97, Shielding for High-Energy Electron Accelerator Installations. Reprints of this Handbook can be purchased as NCRP Report 31 at $2.00 per copy from NCRP Publications, Post Office Box 30175, Washington, DC 20014.

Handbook 102, ASTM Metric Practice Guide. Available as Z 210.1–1976 from the American National Standards Institute, 1430 Broadway, New York, NY 10018 at $4.00.

Handbook 110–1, National Electrical Safety Code. Part 1. Rules for Installation and Maintenance of Electric Supply and Communication Lines (also H30 and H81 and its Supplements). All NBS publications on this subject have been superseded by National Electrical Safety Code, 1977 Edition, issued by the American National Standards Institute, 1430 Broadway, New York, NY 10018. Available from them as ANSI C2, at $6.50.

3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS, 1976[1]

3.1. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 80A, JANUARY-DECEMBER 1976

January-February 1976

Line strengths and lifetimes of levels in neutral uranium, C. H. Corliss, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 1-7 (Jan.-Feb. 1976).

Key words: lifetimes in U I; oscillator strengths for U I; transition probabilities for U I; uranium spectrum.

Relative intensities of 549 U I lines observed in a dc copper arc are used to derive transition probabilities and oscillator strengths. Upper limits to lifetimes for 65 levels in neutral uranium atoms are determined.

Optical properties of nuclear matter, J. S. O'Connell, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 9-13 (Jan.-Feb. 1976).

Key words: absorption cross section; index of refraction; nuclear matter; optical properties; photon; plasma frequency.

The index of refraction and absorptive properties are estimated in nuclear matter consisting of protons and neutrons and in nuclear matter charge neutralized by electrons.

A study of the polarization of fluorescence of ordered systems with application to ordered liquid crystals, E. D. Cehelnik, K. D. Mielenz, and R. B. Cundall, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 15-33 (Jan.-Feb. 1976).

Key words: fluorescence; linear dichroism; liquid crystals; polarization; spectrofluorimetry; 1,6-diphenyl-1,3,5-hexatriene.

The fluorescence polarization of uniaxial molecules dissolved in an ordered medium is studied. A theoretical model is developed which relates the polarization of the fluorescence emission to molecular structure, orientation of absorption and emission dipole oscillators and the degree of ordering. This theory was tested experimentally using all trans 1,6-diphenyl-1,3,5-hexatriene dissolved in an ordered liquid crystal.

PVT and vapor pressure measurements on ethane, G. C. Straty and R. Tsumura, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 35-39 (Jan.-Feb. 1976).

Key words: density; ethane; vapor pressure; *PVT*.

New measurements of the vapor pressures and *PVT* properties of ethane are reported. *PVT* determinations have been made from near the triple point to 320 K at pressures to 33 MPa. The density range investigated extends to more than three times the critical density. The new measurements of the vapor pressures of ethane extend from 160 K to near the critical point.

Functional equations for the enhancement factors for CO_2-free moist air, L. Greenspan, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 41-44 (Jan.-Feb. 1976).

Key words: enhancement factor; moist air; saturated air.

Equations are presented which explicitly express the enhancement of water vapor in CO_2-free air from 0.1 to 2 MPa. The equations are approximations to the formulation of Hyland and provide the means of obtaining enhancement with very modest computational facilities. The agreement with Hyland's enhancement values is well within his estimated uncertainty.

Experimental values for the elastic constants of a particulate-filled glassy polymer. J. C. Smith, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 45-49 (Jan.-Feb. 1976).

Key words: composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; Young's modulus.

Young's modulus and Poisson's ratio have been measured simultaneously on a series of particulate composites containing volume fractions of filler up to 0.50. The composites consisted of small glass spheres imbedded in rigid epoxy polymer matrix. The measured values were compared with theoretical values calculated from current theories. A recently generalized and simplified version of van der Poel's theory provided the best agreement. It predicted values of Young's modulus for composites with filler volume fractions up to 0.35. Measured values of Poisson's ratio exhibited scattering, but were consistent with values calculated from van der Poel's theory.

Heat capacities of polyethylene IV. High molecular weight linear polyethylene, S. S. Chang, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 51-57 (Jan.-Feb. 1976).

Key words: glass transition; heat capacity; high molecular weight linear polyethylene; polyethylene; temperature drift; thermodynamic properties.

A high molecular weight linear polyethylene sample has been studied by adiabatic calorimetry from 10 to 380 K. Two broad temperature regions of unusual spontaneous temperature drift have been observed. The phenomena occurring around 240 K are similar to that observed in other polyethylene samples studied in this series, and are presumed to be caused by the relaxational processes in the amorphous phase. The weak exothermic behavior occurring around 160 K is presumed to be caused by the stabilization of the quenched sample.

Computer simulation of metastable fluid states in the Lennard-Jones system, H. J. Raveché and W. B. Streett, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 1, 59-64 (Jan.-Feb. 1976).

Key words: glassy state; Lennard-Jones system; Monte Carlo simulation; nucleation; overcompression; supercooling.

[1]The various NBS publications series are grouped under subheadings within this section. The several volumes of the Journal of Research are presented consecutively within their appropriate subheadings. If a particular publications series is sought, consult the table of contents or the edge index on the back cover.

Using the Monte Carlo method in statistical mechanics, we have simulated high density metastable states. We find that nucleation from a three dimensional fluid array to a crystalline solid is possible, but that periodic boundary conditions and the small size of the system inhibit the formation of perfect crystals. Evidence for the existence of an amorphous solid state has also been observed, and the pair correlation function of this state exhibits some of the features associated with random close-packed aarays of hard spheres. The possible relation between these simulations and the formation of glassy states in real systems is briefly discussed.

Relative enthalpy of solid beryllium aluminate (chrysoberyl), $BeO \cdot Al_2O_3$, from 1175 to 2025 K, and of liquid beryllium aluminate from 2170 to 2350 K, S. Ishihara and E. D. West, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 1, 65-73 (Jan.-Feb. 1976).

Key words: beryllium aluminate; chrysoberyl; drop calorimetry; enthalpy measurements; high temperature calorimetry; specific heat; thermodynamic properties.

The relative enthalpy of solid beryllium aluminate $BeO \cdot Al_2O_3$ from 1180 to 2025 K and liquid beryllium aluminate from 2170 to 2350 K was measured by "drop" calorimetry using an adiabatic "receiving type" calorimeter. The thermodynamic functions from 1175 to 2025 K and the enthalpy of melting at 2146 K are reported.

March-April 1976

Extinction coefficients of NO_2 and N_2O_4, A. M. Bass, A. E. Ledford, Jr., and A. H. Laufer, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 2, 143-166 (Mar.-Apr. 1976).

Key words: absorption: extinction coefficients; N_2O_4; NO_2; spectra; temperature effects.

The extinction coefficient of NO_2 has been measured in the spectral range 185 to 410 nm as a function of temperature between 235 and 298 K. In order to correct for the effect of the dimer absorption, the extinction coefficient of N_2O_4 has also been measured. The effect of a decrease in temperature upon the NO_2 absorption is a reduction in the extinction coefficient of approximately 10 percent in the range 320 to 380 nm.

A study of the chemiluminescence of the $Pb + O_3$ reactions, M. J. Kurylo, W. Braun, S. Abramowitz, and M. Krauss, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 2, 167-171 (Mar.-Apr. 1976).

Key words: chemiluminescence; electronic states; gas kinetics; laser enhanced reactions; O_3; PbO.

The chemiluminescent reaction of $Pb + O_3$ has been studied using both "cold" an dvibrationally excited O_3. Emission from new states *a* and *b* has been observed in addition to the A and B states. The reaction of vibrationally excited O_3 with Pb to yield PbO(A) appears to be faster than that using "cold" O_3.

Structure- and solvent-property relationships for the electronic energies of charge-transfer complexes between certain benzene derivatives, H. Argentar, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 2, 173-187 (Mar.-Apr. 1976).

Key words: aromatic amine; benzene derivative; charge-transfer complex; dental materials; electron affinity; electron spin resonance spectroscopy; extrathermodynamic relationships; ionization potential; linear free-energy relationship; polarography; solvatochromic relationship; ultraviolet and visible spectroscopy.

A chemical model is proposed for describing charge-transfer complexes between aromatic amines and electron-accepting benzene derivatives containing a group having a double- or triple-bond conjugated with the benzene ring. According to this model, an electron migrates from the nitrogen atom of the amine to one of the atoms of the multiple-bonded group during charge-transfer interaction.

Structure-property relationships were derived for correlating: (1), the transition energies of the complexes; (2), the ionization, or oxidation, potentials of the amines, and (3), the electron affinities or reduction potentials of the electron acceptors, with the electron-donating abilities of the substituents of the various compounds. Transition energies calculated from reported spectroscopic data for these complexes were correlated using equations derived in this study. Similarly correlated were reported data for the above properties of the amine and electron acceptor.

Equations were derived for correlating the effect of variation in solvent on the transition energies of the complexes. Correlation of reported spectroscopic data indicated that the greatest effect is caused by variation in the refractive index; of secondary importance was the change in dielectric constant.

Bidirectional reflectometry. Part I. A high resolution laser bidirectional reflectometer with results on several optical coatings, J. J. Hsia and J. C. Richmond, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 2, 189-205 (Mar.-Apr. 1976).

Key words: barium sulphate; bidirectional reflectance; bidirectional reflectometer; black coating; gonioreflectometer; magnesium oxide; mu sulphur; reflectance; reflectometer; sodium chloride.

A laser-source bidirectional reflectometer that is fully automated and has angular resolution on the order of one degree has been designed and built. The direction of incidence and viewing can be independently varied over an entire hemisphere except for directions more than 77.5° from the normal, and the two directions must be at least 2.5° apart. Bidirectional reflectances for 15 samples of black and white coatings are presented.

Bidirectional reflectometry. Part II. Bibliography on scattering by reflection from surfaces, J. C. Richmond and J. J. Hsia, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 2, 207-220 (Mar.-Apr. 1976).

Key words: bibliography; emittance; heat transfer; measurement techniques; periodic surfaces; polarization; random surfaces; reflectance; reflectance of coherent radiation; scattering; scattering theory; surface roughness; transmittance.

In connection with the work on development of a high resolution laser source bidirectional reflectometer, a large number of papers were collected dealing with various aspects of the geometrical distribution of the radiant energy reflected from surfaces of different types.

Each paper has been classified into one or more classes on the basis of its technical content. There are eight general classes, with several subclasses in some of the general classes.

Because of the interest in this field, the bibliography is being published as a service to the public.

Energy levels, classified lines, and Zeeman effect of neutral thorium, R. Zalubas, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 2, 221-358 (Mar.-Apr. 1976).

Key words: energy levels; thorium; Th I; wavelengths; Zeeman-effect of Th I.

A list of about 9500 classified lines of Th I in the range 2345-29 662 Å is given. Lines in the range 2345-9239 A were observed and measured at NBS. Zeeman effect data for 2281 lines are listed. Lists of 254 even and 322 odd levels including their g values are presented. Among them there are 72 new levels, which were not contained in earlier publications.

May-June 1976

Fluorescence quantum yield measurements, J. B. Birks, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 389-399 (May-June 1976).

Key words: fluorescence lifetime; fluorescence quantum efficiency; fluorescence quantum yields; fluorescence spectrum; fluorescence standards; molecular fluorescence parameters; observed (technical) fluorescence parameters; polarization; radiative and nonradiative transition probabilities; real fluorescence parameters.

Four *molecular fluorescence parameters* describe the behavior of a fluorescent molecule in very dilute ($\sim 10^{-6}$ M) solution: (i) the fluorescence spectrum $F_M(\bar{\nu})$; (ii) the fluorescence polarization P_M; (iii) the radiative transition probability k_{FM}; and (iv) the radiationless transition probability k_{IM}. These parameters and their temperature and solvent dependence are those of primary interest to the photophysicist and photochemist. $F_M(\bar{\nu})$ and P_M can be determined directly, but k_{FM} and k_{IM} can only be found indirectly from measurements of the secondary parameters, (v) the fluorescence lifetime τ_M, and (vi) the fluorescence quantum efficiency q_{FM}, where $k_{FM} = q_{FM}/\tau_M$ and $k_{IM} = (1 - q_{FM})\tau_M$.

The *real fluorescence parameters* $F(\bar{\nu})$, τ and ϕ_F of more concentrated ($c > 10^{-5}$ M) solutions usually differ from the molecular parameters $F_M(\bar{\nu})$, τ_M and q_{FM} due to concentration (self) quenching, so that $\tau > \tau_M$ and $\phi_F < q_{FM}$. The concentration quenching is due to excimer formation and dissociation (rates $k_{DM}c$ and k_{MD}, respectively) and it is often accompanied by the appearance of an excimer fluorescence spectrum $F_D(\nu)$ in addition to $F_M(\bar{\nu})$, so that $F(\bar{\nu})$ has two components. The *excimer fluorescence parameters* $F_D(\bar{\nu})$, P_D, k_{FD} and k_{ID}, together with k_{DM} and k_{MD}, and their solvent and temperature dependence, are also of primary scientific interest.

The *observed* (technical) *fluorescence parameters* $F^T(\bar{\nu})$, τ^T and $\phi_F{}^T$ in more concentrated solutions usually differ from the real parameters $F(\bar{\nu})$, τ and ϕ_F, due to the effects of self-absorption and secondary fluorescence. The technical parameters also depend on the optical geometry and the excitation wavelength. The problems of determining the real parameters from the observed, and the molecular parameters from the real, will be discussed.

Methods are available for the accurate determination of $F^T(\bar{\nu})$ and τ^T. The usual method of determining $\phi_F{}^T$ involves comparison with a reference solution R, although a few calorimetric and other absolute determinations have been made. For two solutions excited under identical conditions and observed at normal incidence

$$\phi_F{}^T/\phi_{FR}{}^T = n^2 \int F^T(\bar{\nu})d\bar{\nu} / n_R{}^2 \int F_R{}^T(\bar{\nu})d\bar{\nu}$$

where n is the solvent refractive index.

Two reference solution standards have been proposed, quinine sulphate in N H_2SO_4 which has no self-absorption, and 9,10-diphenylanthracene in cyclohexane which has no self-quenching. The relative merits of these solutions will be discussed, and possible candidates for an "ideal" fluorescence standard with no self-absorption and no self-quenching will be considered.

Some methods of luminescence efficiency measurements, A. Bril and A. W. de Jager-Veenis, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 401-407 (May-June 1976).

Key words: cathode-ray excitation; luminescence; luminescence standards; phosphors; quantum efficiencies; radiant efficiencies; UV excitation; x-ray excitation.

Methods of absolute and relative radiant and quantum efficiency measurements are described for ultraviolet, visible, cathode-ray and x-ray excitations. Data on some standard luminescent materials are given.

On the actinometric measurement of absolute luminescence quantum yields, J. N. Demas and B. H. Blumenthal, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 409-412 (May-June 1976).

Key words: absolute yield; chemical actinometry; correction factors; luminescence; quantum-flat actinometer; quantum yield.

The theory of the measurement of luminescent quantum yields using chemical actinometry is described. The sample's emission intensity is measured by nearly completely surrounding the sample with an actinometer solution, and the excitation intensity is directly measured with the same type of actinometer. The ratio of the measured sample emission intensity corrected for the fraction escaping through the excitation ports to the measured excitation intensity is the absolute luminescence yield. Equations, a suitable cell design, and computer calculated correction factors for different cell dimensions and optical densities are given. The absolute yield of the actinometer is not needed, only its relative response with wavelength. New quantum-flat actinometers which should greatly simplify the measurements are described.

The calorimetric detection of excited states, J. B. Callis, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 413-419 (May-June 1976).

Key words: absolute quantum efficiency; absolute quantum yield; calorimetry; luminescence; photoacoustic spectrometer; piezocalorimeter; transducers; triplet formation.

Calorimetric techniques offer the photophysicist and photochemist the opportunity to measure a number of parameters of excited states which may be difficult to obtain by other techniques. The calorimetric strategy seeks to measure the heating of a sample resulting from radiationless decays or chemical reactions of excited states. Heating is best measured through volume and pressure transducers, and four calorimeters based on these are described. With calorimetric instrumentation one can perform measurements on samples in the gas, liquid and solid phases over a wide temperature range. Moreover time dependent processes with time constants ranging from microseconds to seconds are amenable to study. Examples of the application of calorimetric techniques to the determination of quantum yields of fluorescence, triplet formation and photochemistry are given.

Fluorescence efficiency of laser dyes, K. H. Drexhage, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 421-428 (May-June 1976).

Key words: aminocoumarins; carbazine dyes; deuterium effect; fluorescence quantum yield; laser dyes; molecular structure; oxazine dyes; quenching; xanthene dyes.

The fluorescence efficiency of xanthene dyes, oxazine dyes, and 7-aminocoumarins is discussed. Relations with the molecular structure are pointed out and dependence on solvent and temperature is explained. Several new fluorescence standards are suggested.

Oscillator strengths for lines of ionized uranium (U II), C. H. Corliss, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 429-438 (May-June 1976).

Key words: oscillator strengths for U II; transition probabilities for U II; uranium spectrum.

Oscillator strengths for 49 lines of U II recently measured by Voight can be used to calibrate the intensity scale of the U II lines in the NBS Tables of Spectral-Line Intensities and derive a larger set of oscillator strengths of lower precision but consistent with the new measurements. The standard deviation of the differences between the two sets of *gf*-values for the 49 lines is 29 percent. Oscillator strengths of that precision are given for 776 additional lines from the NBS Intensity Tables. The uncertainty in absolute value is 67 percent.

Cancer detection by NMR in the living animal, I. D. Weisman, L. H. Bennett, L. R. Maxwell, Sr., and D. E. Henson, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 439-450 (May-June 1976).

Key words: cancer; mice; NMR; spin-lattice relaxation; spin-spin relaxation.

The purpose of this paper is to review *in vivo* NMR experiments on a transplantable tumor in mice and to discuss the feasibility of using noninvasive NMR for cancer detection in humans.

Modulus of natural rubber cross-linked by dicumyl peroxide. III. Some molecular interpretations, possible refinements of theory, and conclusions, L. A. Wood, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 451-463 (May-June 1976).

Key words: cross-linking of rubber; dicumyl peroxide; elasticity theory of rubber; entanglements in rubber; gel point; modulus of rubber; molecular interpretation of rubber elasticity; rubber elasticity; statistical theory of rubber elasticity; swelling of rubber network.

The shear modulus $G = 5.925 \times 10^{-3}(fp - 0.45)T + G^*$ (Part I), its energy component $G^* = 0.0684\ (fp - 0.45) + 2.70$ (Part II), and the number of effective sub-chains per unit volume $\nu_e = (G - G^*)/RT$ are given detailed molecular consideration. G is given in Mdyn cm^{-2} for rubber cross-linked by adding p parts of dicumyl peroxide per hundred of rubber, and heating until a fraction f of the peroxide is decomposed. ν_e is found to be approximately twice the density of cross-links, after a correction for impurities and chain ends is made. It cannot be computed as G/RT since only the entropy component of modulus is related to ν_e. The sub-chains for the most highly cross-linked rubbers studied had a molecular weight of about 575 g mol^{-1}, corresponding to about 8 isoprene units. The modulus corresponding to no added cross-links is not zero. It is determined chiefly by the energy component of the modulus; it does not arise from entanglements. The "front factor" is found to be unity.

An extensive literature survey yields values of the quantity $RT\Psi(\nu_2)$, where $\Psi\ (\nu_2)$ is the Flory-Rehner equation function of ν_2, the equilibrium volume fraction obtained by swelling the cross-linked rubber. $RT\Psi\ (\nu_2)$ is found to be greater than $G - G^*$, but not as large as G itself.

Calculations of configurations of doubly ionized copper (Cu III), J. Sugar and W. C. Martin, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 465-476 (May-June 1976).

Key words: atomic energy levels; atomic spectra; atomic theory; copper; doubly ionized copper; electron configuration.

The energy levels belonging to the configurations $3d^7 4s^2$ and $3d^8 nl$ ($nl = 4s, 5s, 4p, 5p, 4d, 5d, 4f,$ and $5g$) have been calculated. The radial energy integrals were treated as parameters and adjusted to give a least-squares fit to the observed levels. Two- and three-body effective electrostatic interactions for equivalent electrons were included, as well as two-body effective interactions for inequivalent electrons. Strong configuration interaction between $3d^7 4s^2$ and $3d^8 4d$ was taken into account. Values of the parameters are given for all the above configurations, and the calculated levels are given for all except $3d^8 4s$ and $3d^8 4p$ (for which essentially equivalent results have been published). Leading eigenvector percentages are given in appropriate coupling schemes.

The International Practical Temperature Scale of 1968 in the region 90.188 K to 903.89 K as maintained at the National Bureau of Standards, G. T. Furukawa, J. L. Riddle, and W. R. Bigge, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 477-504 (May-June 1976).

Key words: comparator; International Practical Temperature Scale of 1968; IPTS-68; oxygen point; platinum resistance thermometer; temperature standard; tin point; triple point of water; zinc point.

The reproducibility of the International Practical Temperature Scale of 1968 (IPTS-68) in the region 90.188 K to 903.89 K as maintained at the National Bureau of Standards is discussed. The realizations of the triple point of water, the freezing points of zinc and tin, and the boiling point of oxygen are described. The average of the standard deviations of the resistance measurements at the triple point of water of 213 platinum resistance thermometers received for calibration over a two-year period corresponds to ± 0.15 mK. The standard deviations of the resistance ratio $R(T)/R(0\ ^\circ\text{C})$ obtained with check thermometers employed for monitoring the zinc, tin, and oxygen point measurements correspond to ± 0.28 mK, ± 0.30 mK, and ± 0.16 mK, respectively; the results of repeated calibrations with five thermometers show comparable reproducibility at the tin and oxygen points but the reproducibility is worse by a factor of two at the zinc point. When suitably packed for protection from possible mechanical shock platinum resistance thermometers can be shipped by common carrier and retain their calibrations.

Vapor pressure of water at its triple point, L. A. Guildner, D. P. Johnson, and F. E. Jones, *J. Res. Nat. Bur. Stand. (U.S.),* **80A** (Phys. and Chem.), No. 3, 505-521 (May-June 1976).

Key words: precision mercury manometer; triple point of water; vapor pressure of water.

The vapor pressure of water at its triple point was measured with exceptionally high accuracy by realizing it with a special apparatus and measuring the pressure with the NBS precision mercury manometer. The vapor pressure apparatus had a system for circulating the liquid water. Actual triple point conditions were established with a thin sheet of freshly distilled liquid flowing down over an exposed mantle of ice frozen on a vertical well. This technique reduced nonvolatile contaminants and the vapor was repeatedly pumped to remove accumulated volatile contaminants. A diaphragm pressure transducer was used to separate the water vapor from the helium used to transmit the pressure to the manometer. The value found for the vapor pressure of water at its triple point was 611.657 Pa with an uncertainty of ± 0.010 Pa from random errors, computed at 99 percent confidence limits. The systematic errors are estimated to be insignificant relative to the random errors.

July-August 1976

Diffuse reflectance spectroscopy; applications, standards, and calibration (with special reference to chromatography), R. W.

Frei, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 551-565 (July-Aug. 1976).

Key words: chromatography; color matching; color measurement; diffuse reflectance; Kubelka-Munk function; reflectance; reflectance standards; thin layer chromatography.

The multitude of areas in which diffuse reflectance spectroscopy can be applied has been described in several books and reviews and ranges from color measurements of textiles, pharmaceuticals, building materials, paper and pulp materials, etc., to adsorption studies and other basic investigations in physical, inorganic and organic chemistry.

The major area of application is still the measurement of color which has become indispensible in the quality control of colored products, dyes and pigments. Color matching practices and techniques with sophisticated instrumentation which can be fully computerized as well as the use of simpler filter instruments for quality control are mentioned.

Transferability of reflectance data i.e., color coordinates, depends on the quality of standards particularly when absolute measurements are desired. The difficulty of finding suitable "white standards" with good reflection properties at low UV and with a good long term stability is discussed. Similar arguments hold for sphere coating materials. For the measurement of fluorescing surfaces suitable standards are lacking which renders transfer of such data almost impossible.

The usefulness of diffuse reflectance techniques to study adsorption phenomena on small particle adsorbents is demonstrated with a malachite green-*o*-carboxylic acid lactone system studied by Kortüm. This or similar systems could be adopted to the measurement of relative surface areas on certain chromatographic adsorbents yielding more realistic values than the BET-method.

The most recent area of application has been in the field of chromatography for the in situ evaluation of chromatographic zones in flat-bed chromatography, electrophoresis and isoelectric focusing.

In chromatography, standardization is less problematic since usually relative measurements are sufficient. On the other hand one has to find suitable calibration procedures. The use of the Kubelka-Munk function is often questionable since we are usually not dealing with layers of infinite thickness and below 300 nm the conventional adsorbents such as silica gel, alumina or cellulose are strongly absorbing. Experiences with a new function combining the laws of Kubelka-Munk and Lambert-Beer are therefore presented.

The problem is also to find calibration techniques which account for chromatographic parameters. Until recently it was believed that a quantitative evaluation of chromatograms required a number of reference zones to be developed on the same chromatogram. In our experience this is no longer true. A novel calibration technique which utilizes the concept of transferable calibration factors is discussed. With this approach a quantitative evaluation of a chromatogram with only one reference spot is possible. Here again scanning and data acquisition can be fully automated. The application of proper calibration procedures to differential reflectance techniques and the measurement of multicomponent systems is briefly mentioned.

Finally it is demonstrated that it is possible to carry out in situ quantitative measurements on low UV absorbing compounds (down to 190 nm) separated on silica gel surfaces, provided suitable techniques and instrumentation are used.

The interpretation of diffuse reflectance spectra, H. G. Hecht, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 567-583 (July-Aug. 1976).

Key words: absolute absorptivities; continuum models; diffuse reflectance; radiative transfer; reflectance spectra; scattering coefficients; statistical models.

Numerous treatments of the diffuse reflecting properties of scattering media have been described. Many theories give an adequate account of the reflectance for a specific set of conditions for which the model was constructed and the solution tested experimentally. Only those models which are considered to be fairly general are considered here.

It is convenient to divide the theories into those based upon continuum models and those based upon statistical models. The continuum models typically describe the scattering and absorbing properties of a given medium in terms of two phenomenological constants. These models may all be regarded as varying levels of approximate solution to the general equation of radiative transfer. This provides a convenient basis for comparison of the various theories.

The statistical models are based upon a summation of transmittances and reflectances from individual layers or particles. Thus, some assumptions must be made about the nature of the fundamental units, and the validity of the ultimate result will depend upon how closely these assumptions correspond with reality. Only the statistical models lead to expressions from which absolute absorptivities and scattering coefficients can be calculated and related to the actual particle characteristics.

The relationship between the various models will be discussed and the features which typify the absorptivity and scattering coefficient according to each will be compared and related to the available experimental data. This leads to a consideration of the characteristics of appropriate model sytems and standards.

Calibration of reflectance standards, W. Budde, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 585-595 (July-Aug. 1976).

Key words: barium sulfate; diffuse reflectance spectra; magnesium oxide; opal glass; radiant flux; reflectance standards; standards calibration.

Measurements of the diffuse spectral reflectance are usually not made as direct measurement of the incident and the reflected radiant flux but rather as measurements relative to a standard of known reflectance value.

For the calibration of such standards, different methods have been described in the literature: 1. Goniophotometric methods, also called Indicatrix methods or point-by-point methods; 2. Methods based on the Kubelka-Munk theory; 3. Integrating sphere methods according to Taylor, Benford, Sharp-Little, van den Akker, Korte.

Various materials such as magnesium oxide, barium sulfate or opal glass are being used as standards. Their suitability as transfer or as working standards will be discussed.

The results of comparative measurements between some of these methods will be given.

Understanding bidirectional reflectance and transmission for space applications, J. B. Schutt, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 597-603 (July-Aug. 1976).

Key words: bidirectional radiometry; canopies; diffuse reflectance; diffuse transmission; reflectance standards; scattering surfaces.

Applications for optical diffusers in space projects are presented which include the functions of reflection, transmittance, and collection. These modes encompass such diverse uses as temperature regulation and ozone concentration monitors. Discussed is the cooperative aspect of diffuse reflectance and environmental stability. Magnesium oxide, sodium chloride and barium sulphate are evaluated in some detail. The importance of scene scattering behavior to modeling the earth's radiation budget and in determining thermal inertias of the earth's surface are discussed, because solar albedo serves as the weighting function in the solar input irradiance. Finally, work in the area of canopy reflectance modeling is reviewed with verification data included whenever available. Some knowledge of the bidirectional reflectance properties of vegetation is necessary for identification, acreage computations, and scene transferrance.

Standardization of light scattering measurement in conjunction with immunochemical analysis, G. J. Buffone, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 605-608 (July-Aug. 1976).

Key words: antibodies; antigens; biological polymers; immunochemical analysis; light scattering; polymers; proteins; solid standards.

Light scattering methods for the physical analysis of synthetic and biological polymers necessitates the use of scattering standards and absolute light scattering measurements. Standardization has not been employed when light scattering has been used to monitor immunochemical reactions using a kinetic or thermodynamic mode.

The concentration of a specific protein present in a complex matrix such as urine, serum or cerebrospinal fluid, is measured by reacting the protein of interest with its specific antibody and then measuring the excess light scattering of the solution produced by the formation of antigen antibody complexes. The lack of established light scattering standards in the area of immunochemical measurements make instrumental quality control difficult and has hindered direct comparison of data among investigators. Both solid and liquid light scattering standards would be necessary to encompass the wide range of instrumentation currently in use. Several solid standards which have been used in the past include reflecting diffusers such as vitrolite, magnesium carbonate crystal, casein paint on vitrolite, and solid opal glass transmitting diffusers such as flashed opal glass and solid opal glass. These standards, while applicable to manual light scattering photometers, are not suitable for recently developed automated instrumentation. Liquid standards in the form of Ludox®, solutions of polystyrene, suspensions of small diameter latex spheres and even pure organic solvents could be used more easily with the continuous flow and discrete automated analyzers. The introduction of instrumental standards at this level of analysis would result in improved overall quality control and facilitate data and method comparison between laboratories.

Errors in spectrophotometry and calibration procedures to avoid them, A. G. Reule, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 609-624 (July-Aug. 1976).

Key words: bandwidth; calibration; errors in spectrophotometry; interferences; multiple reflections; photometric linearity; polarization; sample characteristics; straylight; wavelength accuracy.

Based on simple principles, spectrophotometry nevertheless demands a lot of precautions to avoid errors. The following properties of spectrophotometers will be discussed together with methods to test them: spectral properties—wavelength accuracy, bandwidth, stray light; photometric linearity; interactions between sample and instrument—multiple reflections, polarization, divergence, sample wedge, sample tilt, optical path length (refractive index), interferences.

Calibration of master instruments is feasible only by complicated procedures. With such a master instrument standards may be calibrated which greatly simplify performance checks of instruments used for practical work. For testing high quality spectrophotometers the use of emission lines and nearly neutral absorbing solid filters as standards seems to be superior, for some kinds of routine instruments the use of absorption bands and liquid filters may be necessary.

Standardization in transmission spectrophotometry in the visible and ultraviolet spectral regions, A. R. Robertson, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 625-630 (July-Aug. 1976).

Key words: errors in spectrophotometry; photometric scale; slit width; spectral transmission; spectrophotometer standards; stray light; wavelength scale.

In an instrument as complex as a spectrophotometer there are many potential sources of error. Because of this it is useful to have available standard materials whose spectral transmittances are known accurately. Periodic measurement of such standards provides a useful indication of whether a spectrophotometer is producing accurate results.

If the spectral transmittance functions of these standards are chosen suitably, the measurements can provide diagnostic information to indicate what type of error is occurring. Among the factors that most often lead to errors in spectrophotometry are the slit-width, the wavelength scale, the photometric scale, and stray radiation. Suitable material standards can provide indications of the occurrence of these errors. However it is sometimes difficult to identify a particular error since often several errors will occur at the same time.

Several sets of standards for testing spectrophotometers are available or can be constructed easily. Most of these are glass filters, but interference filters, perforated screens, and rotating sectors are also used. Liquid filters have some advantages, especially in the ultraviolet where glass filters absorb too strongly to be useful. However difficulties in preparing and handling liquid filters can introduce uncertainties.

It is important that standard materials are insensitive to environmental conditions (such as temperature) and that they are stable over a long period of time. Unfortunately, many of the materials with the most suitable spectral characteristics are least suitable in these respects, and it would be very useful if new and better materials could be developed.

Acidic potassium dichromate solutions as ultraviolet absorbance standards, R. W. Burke and R. Mavrodineanu, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 631-636 (July-Aug. 1976).

Key words: absorbance linearity; accuracy; acidic potassium dichromate solutions; calibration of ultraviolet spectrophotometers; liquid filters; transfer standards; ultraviolet absorbance standards.

The absorbances of five concentrations of potassium dichromate in 0.001 *M* perchloric acid have been determined at eight wavelengths in the ultraviolet on the National Bureau of Standards Institute for Materials Research high-accuracy spectrophotometer. Four of the wavelengths—235, 257, 313, and 350 nm—correspond to absorbance maxima or minima in the $HCrO_4^-$ spectrum and are useful wavelengths for checking the accuracy of the absorbance scale of narrow bandpass spectrophotometers. Although partial dimerization of $HCrO_4^-$ to

$Cr_2O_7^=$ produces small positive deviations from Beer's law at these wavelengths, the apparent absorptivities calculated for each concentration are reproducible to one part in a thousand. The estimated uncertainties in the absorptivity values are ±0.7 percent at 0.1 absorbance (A) and ±0.2 percent near $A = 1$. These uncertainties include all known sources of possible systematic error and the 95 percent confidence level for the mean. The remaining four wavelengths used for measurement are near two predicted isosbestic points in the $HCrO_4^-/Cr_2O_7^=$ spectra. The absorptivities at 345 nm are sufficiently independent of concentration that this wavelength can be used for checking absorbance linearity to one part in a thousand over the range $A = 0.2 - 1$.

Considerations for the use of semitransparent metallic thin films as potential transmittance standards in spectrophotometry, R. Mavrodineanu, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 637-641 (July-Aug. 1976).

Key words: evaporated metal-on-quartz; filters, transmittance; neutral filters; standard reference materials; transmittance characteristics; ultraviolet-visible filters.

Various characteristics of evaporated metal-on-fused silica filters are discussed in relation to their optical transmission properties. Special metal holders provided with shutters were designed to be used with these filters, and are described in detail. Transmittance measurements, performed in various conditions, are reported and indicate that the evaporated metal-on-fused silica filters might present an acceptable material as transfer standards in spectrophotometry.

Structure-related optical characteristics of thin metallic films in the visible and ultraviolet, H. E. Bennett and J. L. Stanford, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 643-658 (July-Aug. 1976).

Key words: absorption; dielectric layers; irregularities; metallic thin films; microirregularities; overcoating; plasmons; scatter.

Surface irregularities and crystalline order strongly influence both the scattered light and absorption of metallic films. These effects extend through all spectral regions but are particularly important in the visible and ultraviolet. Scattered light arises from several scattering mechanisms. Macroscopic irregularities such as dust, scratches and particulates are typically much less important than are microirregularities only a few tens of angstroms in height but covering the entire surface. For metals such as silver and aluminum, which have plasma edges in the ultraviolet, the excitation of surface plasmons resulting from these microirregularities causes additional incoherently reemitted or "scattered" light. Surface plasmon excitation also causes increased absorption in some wavelength regions. These effects are enhanced by dielectric overcoating layers, which both increase the absorption and scattering and shift the wavelength at which the peak occurs. Surface plasmon excitation is particularly important in the ultraviolet region, where the dielectric overcoating applied to prevent formation of an oxide film on aluminized mirrors, for example, can significantly change the mirror reflectance. Plasmon excitation is made possible by a momentum conserving process associated with material inhomogeneities and hence can presumably be caused by crystalline disorder in the metal surface as well as surface irregularities. If the disorder is present on a sufficiently fine scale, it also affects the band structure of the metal and hence its optical absorption. Examples of the effect of film structure on the optical properties of evaporated and sputtered metal films will be given.

Measurement of melting point and radiance temperature (at melting point and at 653 nm) of hafnium-3(wt.%) zirconium by a pulse heating method, A. Cezairliyan and J. L. McClure, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 659-662 (July-Aug. 1976).

Key words: hafnium; high-speed measurement; high temperature; melting point; pyrometry; radiance temperature.

A subsecond duration pulse heating method is used to measure the melting point and radiance temperature (at 653 nm) at the melting point of hafnium containing 3.12 weight percent zirconium. The results yield a value of 2471 K for the melting point on the International Practical Temperature Scale of 1968. The radiance temperature (at 653 nm) of this material at its melting point is 2236 K, and the corresponding normal spectral emittance is 0.39. Estimated inaccuracies are: 10 K in the melting point and in the radiance temperature, and 5 percent in the normal spectral emittance.

Nationwide survey of ^{60}Co teletherapy dosimetry, M. Ehrlich and G. L. Welter, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 663-668 (July-Aug. 1976).

Key words: absorbed dose; cobalt-60 gamma radiation; computation check; dose interpretation; mailings; results; therapy departments; thermoluminescence dosimeters; uncertainty; water phantom.

The National Bureau of Standards is performing a study of the ability of radiation-therapy departments to deliver prescribed absorbed doses of ^{60}Co gamma radiation to a water phantom. Batches of thermoluminescence dosimeters are mailed to participating therapy departments for irradiation under prescribed conditions. Upon return of the dosimeters, the participants' computations are checked and the absorbed dose is evaluated from dosimeter response. The rugged dosimetry system was assembled mainly from commercial components adapted to the present requirements of relatively high flexibility of readout parameters and data-handling techniques, and of relatively high accuracy. The uncertainty in the dose interpretation inherent in the system is estimated to be about 4 percent.

In order to illustrate the type of information that can be obtained from such a study, results of the first four mailings involving tests on 114 ^{60}Co gamma-ray beams are discussed. They show about 75 percent of the dose interpretations to be within 5 percent of the prescribed absorbed dose, and about 20 percent to be within 5 to 10 percent of this dose. Four dose interpretations showed discrepancies larger than 20 percent. Differences in the computations larger than 1 percent were observed in over one-half of the cases.

A self-balancing nanovolt potentiometric system for thermometry and calorimetry, S. S. Chang, *J. Res Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), No. 4, 669-675 (July-Aug. 1976).

Key words: automatic potentiometry; automation; calorimetry; Diesselhorst ring; potentiometer; programmable potentiometer; self-balancing potentiometers; thermometry.

The principle of a self-balancing potentiometric system is described. The principle is applied to the modification of an existing manually operated thermo-free, low voltage potentiometer consisting of Diesselhorst ring elements. The modification involves the addition of reed relays which enable the potentiometer voltage to be set by digital signals. By incorporating a digital voltmeter, or an analog-to-digital converter, and a nanovolt amplifier with the modified potentiometer, self-balancing of the potentiometer may be achieved through either hardware logic implementation or direct digital control from a minicomputer. The resolution of this self-balancing potentiometric system for a full scale input of 100 mV is about one to 10 parts in 10^8. With

real-time digital processing of the data, resolution of about 1 nV or better has been achieved for slowly changing input signals. The overall accuracy of the system is better than 10 ppm for voltage measurements and about 1 ppm for voltage ratio or resistance measurements.

September-December 1976

Deviation of international practical temperatures from thermodynamic temperatures in the temperature range from 273.16 K to 730 K, L. A. Guildner and R. E. Edsinger, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), Nos. 5 and 6, 703-738 (Sept.-Dec. 1976).

Key words: gas thermometry; International Practical Temperature Scale of 1968; temperature scale differences; thermodynamic temperatures.

The range over which thermodynamic temperatures have been realized by gas thermometry at the NBS has been extended to 730 K. The results are preserved by measuring the corresponding international practical temperatures. The difference between them is expressed as the following polynomial:

$$T/\mathrm{K} - T_{68}/\mathrm{K}_{68} = -120{,}887.784/T_{68}^2 + 1213.53295/T_{68} - 4.3159552 + 6.44075647 \times 10^{-3} T_{68} - 3.56638846 \times 10^{-5} T_{68}^2$$

which is valid in the range 273 to 730 K.

The difference found and the estimated uncertainties at the three defining fixed points in the range covered are

t(°C)	$T/\mathrm{K} - T_{68}/K_{68}$	Uncertainty	
		Random (99% confidence limits)	Systematic
100	−0.0252	±0.0018	±0.00054
231.9681	−0.0439	±0.0022	±0.0015
419.58	−0.0658	±0.0028	±0.0028

Measurements of the specific heats, C_σ, and C_v, of dense gaseous and liquid ethane, H. M. Roder, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), Nos. 5 and 6, 739-759 (Sept.-Dec. 1976).

Key words: constant volume; ethane; heat capacity; liquid; saturated liquid; specific heat; vapor.

The specific heats of saturated liquid ethane, C_σ, have been measured at 106 temperatures in the temperature range 93 to 301 K. The specific heats at constant volume, C_v, have been measured at 19 densities ranging from 0.2 to 3.1 times the critical density, at temperatures between 91 and 330 K, with pressures to 33 MPa, at 200 PVT states in all. The uncertainty of most of the measurements is estimated to be less than 2.0 percent. As the critical point is approached the uncertainty rises to about 5.0 percent. The measurements were performed to provide input data for accurate calculations of the thermodynamic properties for ethane. They are believed to be the most comprehensive specific heat measurements available for the liquid and vapor states of ethane.

Phase equilibria and crystal growth in the alkali antimonate systems Sb_2O_4-$NaSbO_3$, Sb_2O_4-$KSbO_3$, and Sb_2O_4-$NaSbO_3$-NaF, J. L. Waring, R. S. Roth, H. S. Parker, and W. S. Brower, Jr., *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), Nos. 5 and 6, 761-774 (Sept.-Dec. 1976).

Key words: alkali antimonates; crystal growth; ionic conductors; potassium antimonate; sodium antimonate; sodium antimony oxyfluoride.

Phase equilibrium diagrams have been constructed from experimental data for the systems Sb_2O_4-$NaSbO_3$, Sb_2O_4-$KSbO_3$, and Sb_2O_4-$NaSbO_3$-NaF. The system Sb_2O_4-$NaSbO_3$ contains only an intermediate pyrochlore type solid solution with a maximum melting point of 1490 °C at a Na:Sb atom ratio of 3:5. The Sb_2O_4-$KSbO_3$ system contains in addition to the pyrochlore phase a compound $3K_2O{\cdot}5Sb_2O_5$ which melts congruently at about 1450 °C and two polymorphs of $K_2O{\cdot}2Sb_2O_5$. The low temperature form of $K_2O{\cdot}2Sb_2O_5$ was found to be monoclinic $P2_1/c$ with $a = 7.178$, $b = 13.378$, $c = 11.985$ A, $\beta = 124°10'$. The melting point of Sb_2O_4 was found to be 1350 ± 5 °C and $NaSbO_3$ and $KSbO_3$ both melt congruently at 1555 ± 5 °C and 1410 ± 5 °C respectively. The previously reported cubic form of $KSbO_3$ was found to be a K^+ deficient phase stabilized by reaction with atmospheric moisture. A similar cubic phase which appears to be a good Na^+ ion conductor can be synthesized in the ternary system $NaSbO_3$-Sb_2O_4-NaF.

Vapor pressure formulation for water in range 0 to 100 °C. A revision, A. Wexler, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), Nos. 5 and 6, 775-785 (Sept.-Dec. 1976).

Key words: Clapeyron equation; saturation vapor pressure over water; steam; vapor pressure; vapor pressure of water; virial coefficients.

In 1971 Wexler and Greenspan published a formulation for the vapor pressure of water encompassing the temperature range 0 to 100 °C. In this paper a revision is made of that earlier formulation to make it consistent with the definitive experimental value of the vapor pressure of water at its triple point recently obtained by Guildner, Johnson, and Jones. The two formulations are essentially identical at temperatures from 25 to 100 °C.

For temperatures below 25 °C the new formulation predicts values that are higher than the 1971 formulation. At the triple point, the vapor pressure given by the new formulation is 611.657 Pa whereas the value given by the 1971 formulation is 611.196 Pa. A table is given of the vapor pressure as a function of temperature at 0.1-deg intervals over the range 0 to 100 °C on the International Practical Temperature Scale of 1968, together with values of the temperature derivative at 1-deg intervals.

Revised lifetimes of energy levels in neutral iron, C. H. Corliss and J. L. Tech, *J. Res. Nat. Bur. Stand. (U.S.)*, **80A** (Phys. and Chem.), Nos. 5 and 6, 787-797 (Sept.-Dec. 1976).

Key words: atomic spectra; energy levels; Fe I; iron; iron lifetimes; lifetimes in Fe I.

Mean radiative lifetimes for 408 energy levels of neutral iron are revised from our 1967 paper on the basis of comparison with 81 subsequently measured lifetimes. The standard deviation of the ratio of the revised values to the reference lifetimes is 30 percent.

3.2. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICAL SCIENCES, VOLUME 80B, JANUARY-DECEMBER 1976

January-March 1976

Nonnegative sums of roots of unity, M. Newman, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 1-4 (Jan.-Mar. 1976).

Key words: algebraic numbers; conjugates; roots of unity.

Let q, n be integers > 1, and let $\rho_1, \rho_2, \ldots, \rho_n$ be distinct qth roots of unity. It is shown that $\rho_1{}^k + \rho_2{}^k + \ldots + \rho_n{}^k \geq 0$ for all integral k if and only if n is a divisor of q and the set $\{\rho_1, \rho_2, \ldots, \rho_n\}$ coincides with the set $\{1, \zeta_n, \zeta_n{}^2, \ldots, \zeta_n{}^{n-1}\}$, where $\zeta_n = \exp(2\pi i/n)$.

Plane-wave scattering-matrix theory of antennas and antenna-antenna interactions: Formulation and applications, D. M. Kerns, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 5-51 (Jan.-Mar. 1976).

Key words: antenna-antenna interactions; antenna measurements; antenna theory; scattering-matrix theory of antennas.

In recent years a considerable amount of theoretical, experimental, and computational work in the development and application of techniques for accurate measurement of microwave antennas has been successfully completed at the National Bureau of Standards (and work is continuing). This paper presents and extends the basic plane-wave scattering-matrix formalism and presents new generalized or adjoint reciprocity relations for antennas. The PWSM formalism is eminently suitable for the formulation and solution of problems involving interactions at arbitrary distances and for the expression of conventional asymptotic quantities, such as gain, effective area, and polarization. It has in particular enabled derivation of two new techniques that permit accurate, "probe-corrected" antenna measurements at greatly reduced distances: (1) by deconvolution of transverse scanning data, taken with $d \ll d_R$ (where $d_R \equiv a^2/2\lambda$) and (2) by extrapolation of received signal observed as a function of distance d, with $d \sim d_R$. These techniques basically determine the scalar product, C, of two vectors characteristic respectively of the transmitting and the receiving antennas. Formulas for utilization of C-data, taking full account of polarization characteristics and not requiring reciprocal antennas, are given for (a) one-unknown-antenna, (b) generalized two-identical-antenna, and (c) generalized three-antenna measurement techniques.

Optimal facility location for normally and exponentially distributed points, I. N. Katz and L. Cooper, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 53-73 (Jan.-Mar. 1976).

Key words: always convergent algorithms; exponentially distributed points; facility location; location theory; normally distributed points; numerical analysis; optimization; stochastic Weber problem.

N destinations in the plane $\{P_j : j = 1, \ldots, N\}$ are given as independent random variables with specified probability densities, and the problem is to find the location of the point P which minimizes the expected sum of the Euclidean distances PP_j.

In this paper, upper bounds for the minimizing sum of distances are found in terms of solutions to corresponding deterministic problems and the first and second moments of the probability densities. Three commonly occurring classes of bivariate probability densities: (A) normal, (B) exponential, and (C) symmetric exponential, are then considered. Numerical tests are presented which show that in all cases, Steffensen's iteration is effective in accelerating convergence. Finally it is shown that in contrast to the deterministic case, P need not be in the convex hull of the means of P_j and a sufficient condition is given for P to be in this convex hull.

Real, 3×3, D-stable matrices, B. E. Cain, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 75-77 (Jan.-Mar. 1976).

Key words: arc-connectedness; Carlson-Johnson conjecture; D-stable; positive stable matrix.

We characterize the 3×3 real D-stable matrices.

Transient solutions for stratified fluid flows, D. W. Fox, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 79-88 (Jan.-Mar. 1976).

Key words: fluid dynamics; fundamental solution, intitial value problem; partial differential equations; stratified flow, internal waves, buoyant flows.

The solution to an initial value problem for the flow of a buoyant inviscid incompressible fluid in three-space is given in terms of a fundamental solution. The initial values and the distribution of source strength can be quite general subject only to mild restrictions on smoothness. The fundamental solution and its associated velocity and displacement fields are given explicitly and in some detail.

Equivalence of partitioned matrices, R. B. Feinberg, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 89-98 (Jan.-Mar. 1976).

Key words: determinantal divisors; equivalence; matric equation; partitioned matrix; Smith normal form.

It is shown that if $M = \begin{bmatrix} A & T \\ 0 & B \end{bmatrix}$ is a partitioned matrix over a principal ideal domain R such that the matrices A and B are both square, then M is equivalent to $A+B$ $\langle = \rangle$ the matric equation $T = AY + XB$ is solvable. The result is generalized to treat the case when

$$M = \begin{bmatrix} M_{11} & M_{12} & \ldots & M_{1t} \\ 0 & M_{22} & \ldots & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ 0 & \ldots & 0 & M_{tt} \end{bmatrix}$$

where each M_{ii} is square.

Tables of binomial coefficients and Stirling numbers, K. Goldberg, F. T. Leighton, M. Newman, and S. L. Zuckerman, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 1, 99-171 (Jan.-Mar. 1976).

Key words: binomial coefficients; modular computation; Stirling numbers.

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Tables of binomial coefficients and of Stirling numbers are given, along with the most important formulas and relationships satisfied by them. The tables were computed using modular arithmetic.

April-June 1976

The dependence of inspection-system performance on levels of penalties and inspection resources, A. J. Goldman and M. H. Pearl, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 189-236 (Apr.-June 1976).

Key words: inspection; mathematical model; regulation; strategy; theory of games.

This paper presents three simple mathematical models, all of game-theoretic type, dealing with an inspector-inspectee relationship. The inspectee always tries to maximize his net gain, which is the amount he obtains by "cheating" less the amount he is penalized when caught. The first model assumes a zero-sum payoff and so the inspector tries to minimize the inspectee's net gain. In the second model, the inspector tries to deter cheating without concern for the extraction of penalties. In the third model we assume that the probabilistic pattern of the inspector's strategy is known to the inspectee and that the inspector constructs his strategy with this in mind. Each of these models is analyzed and optimal solutions are obtained. Several simple examples are presented to show the relation between the level of cheating and the levels of inspection resources and penalty.

A minimax-measure intersection problem, P. R. Meyers, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 237-243 (Apr.-June 1976).

Key words: combinatorial analysis; combinatorial probability; measure theory; minimax.

The problem solved is that of selecting n subsets of the unit interval, each of measure α, so as to minimize the maximum of the measures of their p-fold intersections. This is achieved by minimizing the sum of the measures of these p-fold intersections.

Inverting sparse matrices by tree partitioning, D. R. Shier, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 245-257 (Apr.-June 1976).

Key words: block Gaussian elimination; graph; inversion; partitioning; sparse matrix; tree.

This paper studies the tree partitioning of a graph whose definition is based on the pattern of zero elements present in a given matrix. This partitioning then indicates a particularly advantageous strategy for employing block Gaussian elimination over a certain class of matrices. The strategy is exploited for matrix inversion, where it is especially appropriate for problems which require finding only selected submatrices of the inverse. A graph-theoretic algorithm is given for automatically generating tree partitioning for any matrix. Combinatorial properties of this procedure are also discussed.

The structure of higher degree symmetry classes of tensors, R. Merris, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 259-264 (Apr.-June 1976).

Key words: decomposable (or pure) tensor products; irreducible complex character; orthogonality relations; permutation group.

The paper is concerned with symmetry classes of tensors which arise from a permutation group G and irreducible character χ of G. In case χ is of degree 1, a well-known algorithm is available for inducing a basis of the symmetry class from the underlying vector space. When the degree of χ is greater than 1, no comparable construction has been discovered. The difficulties are discussed and results obtained in some special cases.

The Kronecker power of a permutation, R. Merris, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 265-268 (Apr.-June 1976).

Key words: bell numbers; branching theorem; Clebsch-Gordon series; irreducible character; matrix functions; multiple transitivity; permutation group; Stirling numbers.

Let G be a permutation group of degree n. Think of the elements, σ, of G as n-square permutation matrices. The paper concerns a reduction of the representation $\sigma \rightarrow$ the rth Kronecker power of σ. In case G is the full symmetric permutation group, a formula is given which involves the Stirling numbers of the second kind.

On Iohvidov's proofs of the Fischer-Frobenius theorem, R. C. Thompson, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 269-272 (Apr.-June 1976).

Key words: Hankel matrix; Toeplitz matrix.

A short proof is given of theorem of Fischer and Frobenius exhibiting a conjunctive transformation mapping Toeplitz matrices onto Hankel matrices.

Matrix algebra and eigenvalues for the bead/spring model of polymer solutions, J. T. Fong and A. Peterlin, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 273-284 (Apr.-June 1976).

Key words: bead/spring model; dilute polymer solutions; eigenvalue; hydrodynamic interaction; matrix algebra; necklace model; polymer physics.

Based on purely matrix-algebraic arguments, we prove three new results on the eigenvalue problem [Zimm, 1956] arising from modeling the bulk hydrodynamic and dielectric properties of very dilute polymer solutions:

1. Let N be the number of identical segments joining $N+1$ beads of a bead/spring model for any polymer molecule. Then for any N, the well-known hydrodynamic interaction matrix $\underline{\underline{H}}$ is positive definite if the so-called interaction parameter h^* is less than $(2\sqrt{2}+1)/7$ or 0.547. 2. Let $\underline{\underline{A}}$ be the tridiagonal matrix governing the elastic link force on each bead. Then if $\underline{\underline{H}}$ is positive definite, there exists a matrix $\underline{\underline{Q}}$ such that $\underline{\underline{Q}}^{-1}\underline{\underline{H}}\underline{\underline{A}}\underline{\underline{Q}}=\underline{\underline{Q}}^{T}\underline{\underline{A}}\underline{\underline{Q}}=\underline{\underline{\Lambda}}$, where $\underline{\underline{\Lambda}}$ is a diagonal matrix. 3. (Equivalence Statement due to Lodge and Wu [1971]). The nonzero eigenvalues of the matrix product $\underline{\underline{H}}\,\underline{\underline{A}}$ are completely determined by solving the eigenvalue problem associated with a symmetric matrix $\underline{\underline{S}}$, where $S_{ij}=H_{ij}+H_{i-1,j-1}-H_{i-1,j}-H_{i,j-1}$, $i,j=1,2,\ldots,N$.

To illustrate the significance of these results, numerical output for N as large as 300 based on a Fortran program for several values of h^* is given.

Predictable regular continued cotangent expansions, J. Shallit, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 2, 285-290 (Apr.-June 1976).

Key words: continued cotangent; continued fraction; quadratic irrational.

Expansions of the form $x=\cot(\text{arc cot } n_0 - \text{arc cot } n_1 + \text{arc cot } n_2 - \ldots)$ are discussed. It is shown that if x is of the form $(1/2)(c+\sqrt{c^2+4})$, then the n's are predictable by a simple recurrence.

Continued fractions derived from the expansion of x are also given.

Automatic computing methods for special functions. Part III. The sine, cosine, exponential integrals, and related functions, I. A. Stegun and R. Zucker, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 2, 291-313 (Apr.-June 1976).

Key words: continued fraction; cosine integral; exponential integral; FORTRAN program; hyperbolic sine and cosine integrals; key values; recurrence relations.

Accurate, efficient, automatic methods for computing the sine, cosine, exponential integrals and hyperbolic sine and cosine integrals are detailed and implemented in an American National Standard FORTRAN program. The functions are also tabulated to 35 significant figures for arguments 0, 10^J (10^J) 10^{J+1} with $J=-2(1)2$.

Definite integrals of the complete elliptic integral K, M. L. Glasser, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 2, 313-323 (Apr.-June 1976).

Key words: complete elliptic integral; cubic lattice; definite integral; special functions.

Definite integrals whose integrands contain the complete elliptic integral of the first kind are compiled.

July-September 1976

A note on pairs of matrices with product zero, C. R. Johnson, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 3, 333-335 (July-Sept. 1976).

Key words: eigenvalues; independence; quadratic form; random variable; singular value decomposition.

Pairs of not necessarily hermitian matrices for which $AB=BA=0$ are characterized in terms of the singular values of $A+B$. This provides a generalization and a simpler proof of a classical result on the independence of quadratic forms in normal random variables.

Finding the circuits of a matroid, E. Minieka, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 3, 337-342 (July-Sept. 1976).

Key words: algorithm; graph; matroid; network; operations research.

Given the bases of a matroid, this paper presents a primal algorithm and a dual algorithm for finding the circuits of the matroid.

One-sided tolerance limits for the normal distribution, $P=0.80$, $\gamma=0.80$, R. H. Wampler, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 3, 343-346 (July-Sept. 1976).

Key words: noncentral t-distribution; normal distribution; statistics; tolerance limits.

A table is given of factors k used in constructing one-sided tolerance limits for a normal distribution. This table was obtained by interpolation in an existing table of percentage points of the noncentral t-distribution. The accuracy of the table is estimated, and a comparison is made of the presently computed factors with a previously published approximation.

Spectral measures and separation of variables, D. W. Fox, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 3, 347-351 (July-Sept. 1976).

Key words: convolution; Hilbert space; separation of variables; spectral measure; tensor products.

This article gives an expression for the spectral measure corresponding to a self-adjoint operator for which separation of variables is possible. The construction makes use of the amalgamation theorem for normal operators in a natural way to obtain the required measure as a tensor convolution of the spectral measures of the part operators.

A survey of selected aspects of stratified and rotating fluids, R. G. Rehm, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 3, 353-402 (July-Sept. 1976).

Key words: buoyant flows; geophysical fluid flows; inertial waves; internal waves; rotating fluids; stratified fluids; waves in fluids.

A survey is presented of phenomena in stratified and rotating fluids. Care is taken to define important quantities, to discuss basic concepts, to derive the fundamental equations and to present the basic nondimensional parameters associated with these flows. After a rather extensive section on waves, the analogy between stratified and rotating flows is discussed. Then nonlinear processes and transport and diffusion processes are reviewed. Although this report is rather brief in parts, it displays the rich variety of phenomena in stratified and rotating fluids. It also tabulates many of the important references.

This report also contains a discussion of some applications. Physical oceanography, physical limnology and meteorology are all areas of application in the earth sciences. The variety of application is stressed at the expense of depth and completeness. The more technological application of plumes in bodies of water or in the atmosphere is also discussed.

Finally, some important problem areas are briefly surveyed. These areas are turbulence, nonlinear processes, numerical computation of flows, and further applications.

A more tractable solution to a singular integral equation obtained by solving a related Hilbert problem for two unknowns, J. A. Pennline, *J. Res. Nat. Bur. Stand. (U.S.)*, **80B** (Math. Sci.), No. 3, 403-414 (July-Sept. 1976).

Key words: analytic function; Cauchy principle value; Hilbert problem for two unknowns; singular integral equation; wave-guide boundary problem.

The singular integral equation

$$\int_0^1 \left(\frac{1}{x-\sigma} + \frac{\frac{1}{2}}{x+\sigma} \right) \psi(x)\, dx = h,\ 0<\sigma<1,$$

is converted into another singular integral equation

$$\frac{1}{2}\int_1^\infty \frac{\phi(t)}{t-x}\,dt + \frac{3}{2}\sqrt{x}\int_1^\infty \frac{\phi(t)}{\sqrt{t}(t-x)}\,dt = \frac{-2h}{\sqrt{x}},\ 1<x<\infty,$$

where

$$\phi(x) = \frac{\psi\left(\frac{1}{\sqrt{x}}\right)}{\sqrt{x}}.$$

The former was derived from a boundary value problem in wave guide theory, and the solution is known. By solving a related Hilbert problem for two unknown functions, the solution of the latter integral equation is obtained. Then, the expression

$$\psi(x) = \frac{1}{x}\,\phi\left(\frac{1}{x^2}\right)$$

is compared to the former known expression obtained for $\psi(\chi)$, and the new expression is found to be more tractable.

Sampling expansion for a Languerre-L_ν^α transform, A. J. Jerri, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 3, 415-418 (July-Sept. 1976).

Key words: Laguerre transform; sampling function; Whittaker's cardinal function.

The Whittaker cardinal (or sampling) series expansion, which is associated with a finite limit Fourier transform, has been extended to include other kernels that are solutions of the Sturm-Liouville problem. To date all illustrations on this generalized sampling expansion have been associated with orthogonal functions on finite intervals. In this note, we present a sampling expansion for a Laguerre-L_ν^α transform where we shall use the Laguerre polynomials $L_n^\alpha(x)$ which are orthogonal on the semi-infinite interval $(0, \infty)$ with respect to the weight function $e^{-x}x^\alpha$.

October-December 1976

An inequality for doubly stochastic matrices, C. R. Johnson and R. Bruce Kellogg, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 4, 433-436 (Oct.-Dec. 1976).

Key words: diagonal scaling; doubly stochastic matrix; Perron-Frobenius eigenvalue.

Interrelated inequalities involving doubly stochastic matrices are presented. For example, if B is an n by n doubly stochastic matrix, x any nonnegative vector and $y = Bx$, then $x_1x_2....x_n \leq y_1y_2....y_n$. Also, if A is an n by n nonnegative matrix and D and E are positive diagonal matrices such that $B = DAE$ is doubly stochastic, then $\det DE \geq \rho(A)^{-n}$, where $\rho(A)$ is the Perron-Frobenius eigenvalue of A. These two mentioned inequalities are actually equivalent.

Improved error bounds for second-order differential equations with two turning points, F. W. J. Olver, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 4, 437-440 (Oct.-Dec. 1976).

Key words: error bounds; parabolic cylinder functions; turning points; uniform asymptotic approximations; Weber's equation.

New error bounds are given for approximate solutions of differential equations of the form

$$d^2w/d\zeta^2 = \{u^2(\pm\alpha^2 - \zeta^2) + \psi(u,\alpha,\zeta)\}w$$

in terms of parabolic cylinder functions. Here ζ is a real variable, α is a bounded real parameter, u is a large positive parameter, and $\psi(u,\alpha,\zeta)$ is a continuous function of α and ζ. Zero values of α are admitted.

Pseudointersection graphs, P. J. Slater, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 4, 441-445 (Oct.-Dec. 1976).

Key words: clique; clique graph; intersection graph; pseudointersection graph; set covering.

Pseudointersection graphs are defined and a parameter called the pseudointersection number of a graph, denoted $\omega^*(G)$ and closely related to the intersection number of G, denoted $\omega(G)$, is introduced. Relations between these parameters and conditions for them to be equal are examined. The problem of computing $\omega^*(G)$ is examined.

An efficient linear algebraic algorithm for the determination of isomorphism in pairs of undirected graphs, C. R. Johnson and F. T. Leighton, *J. Res. Nat. Bur. Stand. (U.S.),* **80B** (Math. Sci.), No. 4, 447-483 (Oct.-Dec. 1976).

Key words: graph isomorphism; labels; modified adjacency matrix; spectrum.

An algorithm, complete with a specific FORTRAN implementation, is presented for the problem of determining whether or not two undirected graphs are isomorphic. The algorithm, centered upon the eigenvalues and eigenvectors of a modified adjacency matrix and techniques for decreasing the size of the automorphism group, is quite different from others (most of which are combinatorially based) and tends to work relatively very quickly on difficult test cases as well as on typical examples. Complexity estimates are given for many eventualities.

3.3. PAPERS FROM THE JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA, VOLUME 5, JANUARY-DECEMBER 1976

This journal is published quarterly by the American Chemical Society and the American Institute of Physics for the National Bureau of Standards. The objective of the Journal is to provide critically evaluated physical and chemical property data, fully documented as to the original sources and the criteria used for evaluation. Critical reviews of measurement techniques, whose aim is to assess the accuracy of available data in a given technical area, are also included. The principal source for the Journal is the National Standard Reference Data System (NSRDS). The Journal is not intended as a publication outlet for original experimental measurements such as are normally reported in the primary research literature, nor for review articles of a descriptive or primarily theoretical nature.

Volume 5, No. 1

Scaled equation of state parameters for gases in the critical region, J. M. H. L. Sengers, W. L. Greer, and J. V. Sengers, *J. Phys. Chem. Ref. Data* **5**, No. 1, 1-52 (1976).

Key words: air constituents; critical region parameters; ethylene; heavy noble gases; helium; linear model; methane; NBS equation; scaling laws; statistical analysis; steam; universality.

The anomalous thermodynamic behavior of fluids near the critical point can be described in terms of scaling laws. In this paper we consider two critical region equations of state, to be referred to as the NBS equation and the Linear Model parametric equation, that satisfy the scaling laws. A complete formulation of the thermodynamic properties in terms of the two equations is given. The statistical methods used for fitting these equations to experimental data are described. Each of the equations is fitted to experimental equation of state data for six fluids, namely He^3, He^4, Xe, CO_2, O_2, and H_2O. An evaluation of the recorded experimental material is included. We find that the two equations represent the experimental data in the range $|T-T_c|/T_c<0.03$ and $|\rho-\rho_c|/\sqrt{\rho_c}<0.25$ equally well and that the exponents and amplitudes of the power laws deduced from the two equations agree closely. The optimum critical exponents appear to vary little from substance to substance. Moreover, a restricted version of the Linear Model with only two freely adjustable constants, in addition to the critical point parameters and the critical exponents, fits the data well in most cases, in agreement with expectations based on universality of critical behavior. The principle of universality is discussed and applied to predict critical region parameters for nine additional fluids, including several for which only limited experimental information is available. These additional fluids are Ar, Kr, N_2, H_2, CH_4, C_2H_4, SF_6, NH_3, and D_2O. We thus conclude with a single universal equation for the critical region of all fifteen fluids considered in this paper.

Microwave spectra of molecules of astrophysical interest. IX. Acetaldehyde, A. Bauder, F. J. Lovas, and D. R. Johnson, *J. Phys. Chem. Ref. Data* **5**, No. 1, 53-78 (1976).

Key words: acetaldehyde; internal rotation; interstellar molecules; microwave spectrum; radio astronomy; rotational transitions.

The microwave spectrum of acetaldehyde is critically reviewed and augmented through calculations which include the effects of internal rotation and centrifugal distortion. Since the primary objective of this review is to provide microwave spectral transitions applicable to radio astronomy studies, the review encompasses only the ground state rotational spectrum of the most abundant isotopic form of acetaldehyde, $^{12}CH_3{}^{12}CH^{16}O$. While all measured transitions are included, the predicted transition frequencies were limited to $J\leqq12$ in the range of 900 MHz to 250 GHz. In addition to this spectral information, the review includes the rotational constants, centrifugal distortion constants, inertial rotation parameters, electric dipole moment, structural data, moments of inertia, and constants relating to the barrier to internal rotation.

Microwave spectra of molecules of astrophysical interest. X. Isocyanic acid, G. Winnewisser, W. H. Hocking, and M. C. L. Gerry, *J. Phys. Chem. Ref. Data* **5**, No. 1, 79-102 (1976).

Key words: isocyanic acid; interstellar molecules; microwave spectra; molecular parameters; rotational transitions; radio astronomy.

The available data on the microwave spectrum of isocyanic acid are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, centrifugal distortion parameters, dipole moments, hyperfine coupling constants, and structural parameters are tabulated. Detailed centrifugal distortion calculations have been carried out for all isotopic forms of this molecule, including DNCO. Transitions have been predicted for the parent molecule for the frequency range 160 MHz-300 GHz. All predicted transitions include error limits. The quoted uncertainties represent one standard deviation. A 95 percent confidence limit is obtained by using approximately twice the calculated standard deviation. Estimated error limits for the measured transitions are discussed. References are given for all data included.

Diffusion in copper and copper alloys. Part IV. Diffusion in systems involving elements of group VIII, D. B. Butrymowicz, J. R. Manning, and M. E. Read, *J. Phys. Chem. Ref. Data* **5**, No. 1, 103-200 (1976).

Key words: alloys; cobalt; copper; diffusion; electromigration; iron; nickel; palladium; platinum; rhodium; ruthenium; thermomigration.

A survey, comparison, and critical analysis is presented of data compiled from the scientific literature concerning diffusion in copper alloy systems involving elements in Group VIII (Co, Fe, Ni, Pd, Pt, Rh, Ru). Here the term "copper alloy system" is interpreted in the broadest sense. For example, the review of diffusion in the Cu-M system reports all diffusion situations which involve both copper and element M, including diffusion of Cu in M or in any binary, ternary or multicomponent alloy containing M; diffusion of M in Cu or in any alloy containing Cu; and diffusion of any element in any alloy containing both Cu and M. Topics include volume diffusion, surface diffusion, grain boundary diffusion, tracer diffusion, alloy interdiffusion, electromigration, thermomigration, dislocation-pipe diffusion, and diffusion in molten metals. An extensive bibliography is presented along with figures, tabular presentation of data and discussion of results.

Volume 5, No. 2

A critical review of the Stark widths and shifts of spectral lines from non-hydrogenic atoms, N. Konjevic and J. R. Roberts, *J. Phys. Chem. Ref. Data* **5**, No. 2, 209-258 (1976).

Key words: experimental; neutral atom; review; shift; Stark broadening; width.

A critical review of all available data on the Stark broadening and shifts of spectral lines of neutral elements has been undertaken. Over 200 papers compiled by the NBS Data Center on Atomic Line Shapes and Shifts have been evaluated, and of these, 68 were chosen as having reviewable data. Only those papers with properly determined critical factors, such as electron density, temperature, spatial homogeneity, optical depth, and instrument function deconvolution, were selected.

Experimental Stark widths and shifts for non-hydrogenic spectral lines of ionized atoms. (A critical review and tabulation of selected data), N. Konjevic and W. L. Wiese, *J. Phys. Chem. Ref. Data* **5**, No. 2, 259-308 (1976).

Key words: critically evaluated data; experimental; ionized spectra; Stark broadening parameters; Stark shifts; Stark widths.

A critical review of all available data on the Stark widths and shifts for lines of non-hydrogenic ionized spectra has been carried out. The relevant literature compiled by the NBS Data Center on Atomic Line Shapes and Shifts was critically evaluated, and from this evaluation 54 papers were found to satisfy all requirements and thus selected for this review. The most important factors determining the quality of plasma sources, diagnostic techniques, and line profile and shift determinations are discussed in detail in the first part of this review. In the second part the data tables containing the selected experimental Stark broadening parameters are presented. The data are arranged according to spectra and elements, and these are presented in alphabetical order. The accuracy of the experimental data is estimated on the basis of guidelines developed during the review, and comparisons with theoretical results are made whenever possible.

Atlas of the absorption spectrum of nitric oxide (NO) between 1420 and 1250 Å, E. Miescher and F. Alberti, *J. Phys. Chem. Ref. Data* **5**, No. 2, 309-318 (1976).

Key words: absorption spectrum; identification atlas; nitric oxide; Rydberg series.

This atlas presents the absorption spectrum between 1420 and 1250 Å of cold (−180 °C) nitric oxide gas, both $^{14}N^{16}O$ and $^{15}N^{16}O$, photographed in first order of a 10.5 m vacuum spectrograph. The spectral region comprises the Rydberg series (*s*-, *p*-, *d*-, and *f*-) of the molecule, including their limits of v=0, 1, and 2 of the ground state of the ion NO^+. In addition it shows some valence bands. To each band are assigned quantum numbers. The assignment is based on the detailed study of the fine structure of the bands, measured on spectral plates obtained in high order of the same instrument. Accurate numerical results of these measurements are tabulated for 140 molecular levels. A short survey on the NO absorption spectrum is given.

Ideal gas thermodynamic properties of propanone and 2-butanone, J. Chao and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* **5**, No. 2, 319-328 (1976).

Key words: enthalpy; entropy; equilibrium constant of formation; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; internal rotational barrier height; propanone (acetone); torsional frequencies; 2-butanone (methyl ethyl ketone).

The ideal gas thermodynamic properties ($C_p°$, $S°$, $H°-H_0°$, $(H°-H_0°)/T$, $-(G'-H_0°)/T$, $\Delta Hf°$, $\Delta Gf°$, and log Kf) for propanone and 2-butanone in the temperature range from 0 to 1500 K and at 1 atm were calculated by statistical mechanical procedures, using rigid-rotor and harmonic-oscillator approximations. The internal rotation contributions to thermodynamic properties were evaluated by use of a partition function formed by summation of internal rotation energy levels. The calculated heat capacities and entropies are in agreement with the available experimental values.

Refractive index of alkali halides and its wavelength and temperature derivatives, H. H. Li, *J. Phys. Chem. Data* **5**, No. 2, 329-528 (1976).

Key words: alkali halides; optical constants; refractive index; temperature coefficient of refractive index.

Refractive index data for 20 alkali halides are exhaustively surveyed, compiled, and analyzed. The most probable values at 293 K for the transparent region are generated for the materials for which experimental data are sufficiently abundant and reliable. Provisional values are also provided for the wavelength regions where available data are insufficient or missing. Reasonable estimations of refractive index for the very scantily measured materials were made by incorporating the dielectric constants and wavelengths of absorption peaks into a simplified dispersion equation. Temperature derivatives of refractive index for most of the alkali halides were unavailable. However, using the existing data for the five most commonly used alkali halides, novel empirical facts were discovered and dn/dT formulas were constructed for all of the alkali halides. The calculated dn/dT values agree remarkably well with the existing experimental data.

Volume 5, No. 3

Tables of critically evaluated oscillator strengths for the lithium isoelectronic sequence, G. A. Martin and W. L. Wiese, *J. Phys. Chem. Ref. Data* **5**, No. 3, 537-570 (1976).

Key words: *f*-values; isoelectronic sequence; lithium sequence; oscillator strengths; relativistic effects; spectral series; systematic trends.

Oscillator strengths for the lithium isoelectronic sequence have been critically evaluated and compiled by means of a new generalized analysis which makes use of several types of systematic trends and fundamental spectroscopic constraints. Relativistic effects have also been considered. The data are presented in separate tables for each ion of the sequence from Li I through Ni XXVI, and are arranged within each table according to spectral series. Separate tables are presented for the $2s$-$2p$ and $2s$-$3p$ transitions, with both relativistic and nonrelativistic *f*-values listed for all ions of the sequence through Ni XXVI, as well as for a few selected ions of higher nuclear charge. The general tables contain transitions of the type *ms-np*, *mp-ns*, and *mp-nd*, with $2 \leq m \leq 4$ (m is the lower principal quantum number) and $3 \leq n \leq 7$. Since most recommended data were determined from a nonrelativistic analysis, hydrogenic relativistic considerations were applied to estimate when the data would be significantly altered by the inclusion of relativistic effects, and such *f*-values were excluded from the tabulation.

Ideal gas thermodynamic properties of six chlorofluoromethanes, S. S. Chen, R. C. Wilhoit, and B. J. Zwolinski, *J. Phys. Chem. Ref. Data* **5**, No. 3, 571-580 (1976).

Key words: chlorofluoromethanes; ideal gas thermodynamic functions; principal moments of inertia; standard enthalpy of formation; vibrational fundamentals.

Spectroscopic and thermal data were reviewed. The selected values for the principal moments of inertia, the vibrational fundamentals, and the standard enthalpy of formation at 298.15 K for each of the six chlorofluoromethanes were used to derive the chemical thermodynamic properties of molecules from 0 to 1500 K, based on the rigid-rotor harmonic-oscillator approximation. The calculated values are in accord with experimental heat capacities and entropies.

Survey of superconductive materials and critical evaluation of selected properties, B. W. Roberts, *J. Phys. Chem. Ref. Data* **5,** No. 3, 581-822 (1976).

Key words: bibliography; composition; critical fields; critical temperature; crystallographic data; low temperature; superconductive materials; superconductivity.

This publication includes all data on superconductive materials intercepted through March 1975. Data on the bulk elements have been critically evaluated, and values on alloys, compounds, and other forms have been selected and condensed to indicate the probable value and spread of values observed. Proven nonsuperconductors have been noted. Conflict in data values has been noted. All data have been keyed to the literature in one or more of the tables. Special subdivisions are presented for superconductive materials with organic constituents and for those based on semiconductive materials. The properties presented are superconductive critical temperature, critical magnetic fields, material state and composition including crystal-structure type where noted, a key to thin-film forms, and the presence of thermodynamic data (generally the electronic specific heat, γ, and Debye θ). High-magnetic-field superconductors are noted with listing of H_{c1}, H_c, H_{c2}, and H_{c3} plus the temperature of observation T_{obs}.

Volume 5, No. 4

Nuclear spins and moments, G. H. Fuller, *J. Phys. Chem. Ref. Data* **5,** No. 4, 835-1092 (1976).

Key words: evaluated data; nuclear electric hexadecapole moments; nuclear electric quadrupole moments; nuclear magnetic dipole moments; nuclear magnetic octupole moments; nuclear spins.

A summary of nuclear-moment values and an index, arranged by Z and A, is presented. The summary value is based on the experimentally determined values of the nuclear moments which have been listed in tables according to the techniques used. Each table is preceded by a short introduction describing the experimental technique involved and the method of calculating the moment from the measured quantities. References are given for all data quoted. The date for the last systematic literature search is included with each table. This tabulation supplements and revises the earlier tables which appeared in Nuclear Data Tables, Volume A5, 433-612 (1969).

Nuclear moments and moment ratios as determined by Mössbauer spectroscopy, J. G. Stevens and B. D. Dunlap, *J. Phys. Chem. Ref. Data* **5,** No. 4, 1093-1122 (1976).

Key words: Mössbauer; nuclear electric quadrupole moments; nuclear magnetic dipole moments.

Values are given for Mössbauer effect measurements of nuclear magnetic moments, spectroscopic quadrupole moments, ratios of moments between low lying excited states and the ground state of the same isotope, and ratios of moments between states of different isotopes. Adopted values for moments, obtained by direct selection of specific results or by an averaging process, are presented. The literature has been covered through December 1974.

Rate coefficients for ion-molecule reactions I. Ions containing C and H, L. W. Sieck and S. G. Lias, *J. Phys. Chem. Ref. Data* **5,** No. 4, 1123-1146 (1976).

Key words: chemical kinetics; data evaluation; gas phase; hydrocarbons; ion-molecule reactions; mass spectrometry; rate coefficients.

A compilation is presented of experimentally determined bimolecular and third order rate coefficients for the reactions of hydrocarbon ions with neutral molecules in the vapor phase. The literature covered is from 1960 to the present, and both positive and negative ions are considered. Four hundred and fifty-eight separate reaction-pairs are tabulated, and the ionic reaction products and experimental conditions are specified wherever possible. Preferred values are suggested for a number of these processes.

Microwave spectra of molecules of astrophysical interest. XI. Silicon Sulfide, E. Tiemann, *J. Phys. Chem. Ref. Data* **5,** No. 4, 1147-1156 (1976).

Key words: interstellar molecules; microwave spectra; radio astronomy; rotational transitions; silicon sulfide; spectra.

The available data on the microwave spectrum of silicon sulfide are critically reviewed for information applicable to radio astronomy. Molecular data such as rotational constants, electric dipole moment and hyperfine coupling constant are tabulated. Observed rotational transitions are presented for all measured isotopic forms of SiS. These data have been analyzed in order to predict rotational transition of the ground vibrational state up to 300 GHz. From the given rotational constants transition frequencies in excited vibrational states can be calculated with little loss in accuracy.

Error limits have been taken from the original literature for each measured frequency. The predicted transition frequencies are given with uncertainties which represent the 90 percent confidence limit.

3.4. DIMENSIONS/NBS, ARTICLE TITLES ONLY

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS.

DIMENSIONS/NBS highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, DIMENSIONS/NBS reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing. Issued monthly.

January 1976

DIM/NBS 60, No. 1, 1-24 (1976).

Key words: computer; energy measurement; EPIC; FIPS; kitchen ranges; mercury; metal fires; metric; safety; WWV/WWVH.

NBS Develops New Mercury Monitor
An EPIC Undertaking: Out of the Classroom, Into the Plant
Metal Fires – Science and Safety
Government Primes the Industrial Pump
WWV/WWVH User's Guide Published by NBS
DOC-GSA Cooperate in Purchase of More Efficient Kitchen Ranges
NBS Makes Computer Network Access Easier
Complete Set of FIPS Available from NBS
NBS, EPRI Sign Cooperative Agreement on Energy Measurement Technology
NBS Establishes Speakers Bureau for Metric Information

February 1976

DIM/NBS 60, No. 2, 1-25 (1976).

Key words: computer systems; environmental; fire; glass door; lead nitrate; mercury thermometers; metric; nuclear power; police radars; solar energy; SRM's.

The Unseen Menace: A Glass Door
America Joins a Metric World
Computer Systems of the 1980's
Mercury Thermometers – Are They Becoming Antiques?
Highlights
Evaluating Economic Performance of Solar Energy Systems
Papers Solicited for Major Environmental Conference
Lead Nitrate SRM Now Available
Lag Time for Nuclear Power Plant Standards
Fire Symposium Scheduled as 75th Anniversary Event
Simple Calibration System for Police Radars Developed by NBS

March 1976

DIM/NBS 60, No. 3, 1-24 (1976)

Key words: batteries; dental materials; industry; integrated utilities system; mass spectrometry; motorized criminal; ozone puzzle; portable transceiver batteries; RF power meter; utilities system.

Catching the Motorized Criminal Scientifically
Another Piece of the Ozone Puzzle
Better Dental Materials Mean Fewer Trips to the Dentist
NBS RAPS With Industry
Highlights
University of Florida, Gainesville, Selected to Test Integrated Utilities System Concepts

NBS Issues Privacy Act Index
New Publication Available on Secondary Ion Mass Spectrometry
Standard Issued for Police Portable Transceiver Batteries
New RF Power Meter Design Available to Manufacturers
Publications

April 1976

DIM/NBS 60, No. 4, 1-24 (1976).

Key words: cryogenic fluid; door locks; energy; EPIC supplement; high winds; home security; nondestructive evaluation; research associate program; school systems; smoke detectors; teaching metric.

Houses vs. High Winds
Life-Saving Investments – Smoke Detectors for the Home
NBS Nondestructive Evaluation Program
Home Security Starts at Your Door
Highlights
Metric Activity Continues to Accelerate in Nation's School Systems
Successes in Teaching Metric Described in Publication
Supplement to Energy Saving Handbook, EPIC, Available
NBS Issues Aids for COBOL Program Conversion
Key to Data on Cryogenic Fluid Mixtures Published
New Research Associate Program for Metal SRM's
Publications

DIM/NBS 60/Suppl., Anniversary Issue, 1-32 (1976).

Key words: computer age; data system; materials research; measurement challenge; science and technology; sea of data; standard reference data system.

"Let Us Raise a Standard to Which the Wise and Honest Can Repair"
Meeting the Measurement Challenge
NBS Through the Years
75 Years of Progress Through Materials Research
Science and Technology for People
Standards for a Computer Age
Staying Afloat in a Sea of Data: National Standard Reference Data System

May 1976

DIM/NBS 60, No. 5, 1-24 (1976).

Key words: building collapse; corrosion; energy; environmental; frequency standards; hearing aids; high-rise buildings; metals; radiation safety; standards laboratory; synchrotron.

Listen Closely – Testing Hearing Aids for Veterans
A Sage of Radiation Safety

Tracking Our Invisible Enemies—New Instrument Aids Environmental Analysis
Toward a National Energy Policy
Highlights
NBS Hosts Anniversary Symposium of Standard Laboratory Experts
Information Guides on Ceramics and Corrosion of Metals Published
Wind Research Aids Designers and Occupants of High-Rise Buildings
NBS Publishes Bibliography on Building Collapse Due to Abnormal Loading
July Date for Frequency Standards Symposium in Colorado
NBS Offers Users Guide for New Synchrotron
Publications

June 1976

DIM/NBS 60, No. 6, 1-24 (1976).

Key words: air conditioners; attic fans; basic research; chemical thermodynamics; door security; Elliot Richardson; energy conservation; engineering; fashion; flammability; laser measurement; science.

Attic Fans and Air Conditioners
NBS Engineers Take a Look at Summer Energy Conservation
Engineering in the Future—A New Profession
Science and Fashion
NBS Develops Proposed Garment Flammability Guidelines
Adventure Into the Unknown: Elliot Richardson Views Basic Research
Highlights
NBS Develops Door Security Standard
Symposium on Chemical Thermodynamics Planned
NBS Begins New Program to Check Laser Measurement Procedures
Publications

July 1976

DIM/NBS 60, No. 7, 1-24 (1976).

Key words: bike regulations; bomb disarmament; computer auditing; energy options; explosive vapor detectors; firebug; impulse generators; MHD electrode materials; optical standards; safety wheels.

Safety on Wheels
NBS Contributes to New Bike Regulations
Computer Auditing Increasingly a Necessity
Energy Options for the Future
Profile of a Firebug
Highlights
Promising MHD Electrode Materials Reported
Standard Issue on Bomb Disarmament X-Ray Systems
Free Service for Explosive Vapor Detectors
Calibration Service Offered for Impulse Generators
Manual for New Optical Standards Available
Publications

August 1976

DIM/NBS 60, No. 8, 1-24 (1976).

Key words: architectural heritage; fire; guardrail; high-capacity; mathematics; mercury; performance standard; pressure transducers; SRM; surgical implants; testing; thermal transients.

NBS "Fall Guy" Provides Basis for Guardrail Performance Standard
The Role of Mathematics in the Real World
A New Lease on an Active Life Through Surgical Implants
Preserving America's Architectural Heritage
Highlights
Test Method Determines Effect of Thermal Transients on Pressure Transducer Response
Most Fire Deaths Occur at Home
SRM Aids in Measuring Industrial Mercury Exposure
NBS to Offer Additional Service for High-Capacity Mechanical Testing
Publications

September 1976

DIM/NBS 60, No. 9, 1-24 (1976).

Key words: computer; consumer; drugs; electrical pulses; environmental standards; friction measurement; lead poisoning; LNG data; optical; standard reference materials; thermophysical properties symposium; waste heat.

The Consumer Comes Face to Face With the Computer
Is This Slip Necessary?
Why Waste Heat?
Research Casts New Light on an Old National Health Problem: Lead Poisoning
Highlights
Sampler Measures Optical and Electrical Pulses
Crime Labs Aided by Standard Reference Materials
NBS-FDA To Develop Systems for Monitoring Newly Approved Drugs
Call for Papers Issued for Thermophysical Properties Symposium
Computer Documentation Guidelines Issued
NBS to Publish LNG Data
Cryogenic Activities Described
Accuracy in Environmental Standards is Theme of Symposium
Publications

October 1976

DIM/NBS 60, No. 10, 1-24 (1976).

Key words: building industry; calibration system; centigrade/celsius; computer; electrical industries; environments; glass standards; government intervention; heating/cooling; lead-paint; metric; pressure transducers; thermal comforts; weights and measures.

Weights and Measures—New Challenges in Today's Marketplace
The Money Side of the Lead Paint Problem
The Consumer Comes Face-to-Face With the Computer
A Primer on Temperature Scales: Centigrade/Celsius, Fahrenheit, Kelvin
Monitoring the Exchange of Power: New Calibration System for Electrical Industries
Highlights
Two New Glass Standards
Computer Program for Heating/Cooling Loads in Buildings Available
Direct Government Intervention Would Have Little Impact on Investment in Small, Technology-Based Companies
Symposium to Examine Thermal Comfort and Indoor Environments
Dynamic Pressure Source Developed for Calibration of Pressure Transducers

Issues Involved in Converting U.S. Building Industry to Metric Explained
Publications

November 1976

DIM/NBS 60, No. 11, 1-24 (1976).

Key words: computer power; computer standard; corrosion; environment; health care; housing production; I-R 100 awards; NIKE missile; papers available; stereology; toy safety; x-ray units.

MIUS May Provide Key to Increased Housing Production
Government Agencies Look to Private Companies for Computer Power
A Measured Environment: The Problem of Policy Versus Practicality
NIKE Missile Site Revisited
Highlights
Conference Planned on Corrosion of Metals in Buildings
Current Developments in Stereology Published
Catalog of 1975 Papers Available
NBS Scientists Win Four Awards in I-R 100 Competition
Calibration Service for Diagnostic X-Ray Units Provided
Report to Aid in Developing Computer Standard
NBS Publishes Voluntary Toy Safety Standard
Use of Color in Health Care Institutions to be Topic of Special Workshop
Publications

December 1976

DIM/NBS 60, No. 12, 1-24 (1976).

Key words: air; building codes; computer tapes; energy; fire; helmets; mobile homes; phase diagrams; tire pressure.

"And Please Check the Air"
Is There More Than One Way to Erase a Tape?
How Fares the Mobile Home in Wind, Fire, and Energy Use?
Keeping Heads Together
Highlights
A Rational Framework for Organization of Building Codes and Specifications Proposed
Workshop on Applications of Phase Diagrams Scheduled for January
Index

3.5. MONOGRAPHS

Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Monogr. 25, Section 13. **Standard x-ray diffraction powder patterns. Section 13—Data for 58 substances,** M. C. Morris, H. F. McMurdie, E. H. Evans, B. Paretzkin, J. H. de Groot, C. R. Hubbard, and S. J. Carmel, *Nat. Bur. Stand. (U.S.), Monogr. 25, Sec. 13,* 114 pages (June 1976) SD Catalog No. C13.44:25/Sec. 13.

Key words: crystal structure; integrated intensities; lattice constants; peak intensities; powder patterns; reference intensities; standard; x-ray diffraction.

Standard x-ray diffraction patterns are presented for 58 substances. Thirty-one of these patterns represent experimental data and 27 are calculated. The experimental x-ray powder diffraction patterns were obtained with an x-ray diffractometer. All d-values were assigned Miller indices determined by comparison with computed inter-planar spacings consistent with space group extinctions. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible. The calculated x-ray powder diffraction patterns were computed from published crystal structure data. Both peak height and integrated intensities are reported for the calculated patterns.

Monogr. 150. **Liquid-in-glass thermometry,** J. A. Wise, *Nat. Bur. Stand. (U.S.), Monogr. 150,* 30 pages (Jan. 1976) SD Catalog No. C13.44:150.

Key words: calibration; emergent stem; liquid-in-glass thermometer; reference point; stirred liquid comparison bath; temperature scale.

This Monograph, which supersedes NBS Monograph 90, contains information of general interest to manufacturers and users of liquid-in-glass thermometers. Instructions explaining how to submit a thermometer to the National Bureau of Standards for calibration are provided, and the techniques and equipment, such as stirred liquid comparison baths, used in the calibration procedures are described. A discussion of important principles of acceptable thermometer design and factors affecting their use is included. Listed are tables of tolerances reflecting good manufacturing practices and reasonably attainable accuracies expected with liquid-in-glass thermometers. The calculation of corrections for the temperature of the emergent stem is given in detail for various types of thermometers and conditions of use.

Monogr. 151. **Automatic measurement of network parameters—A survey,** R. W. Beatty, *Nat. Bur. Stand. (U.S.), Monogr. 151,* 113 pages (June 1976) SD Catalog No. C13.44:151.

Key words: automatic network analyzers; computer-controlled measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; rotating probe devices; slotted lines; survey of automatic techniques; swept frequency measurements; Wheatstone Bridge.

A survey is made of principles, methods, and systems developed for semiautomatic and automatic measurement of network parameters, such as the complex scattering coefficients, impedance, VSWR, return loss, attenuation, and group delay time. The period covered is from 1922 to 1975 and developments range from simple ideas such as a motor driven probe for a slotted line, to computer-controlled transmission and reflection measurement systems.

The essential ideas and features of each development are briefly described and both similarities and differences between various schemes are pointed out. Trends in modern developments are noted and some of the options open for future work are mentioned. A bibliography of 151 references is included.

Monogr. 153. **The first spectrum of hafnium (Hf I),** W. F. Meggers and C. E. Moore, *Nat. Bur. Stand. (U.S.), Monogr. 153,* 117 pages (July 1976) SD Catalog No. C13.44:153.

Key words: analysis, Hf I spectrum; hafnium, analysis of first spectrum; spectrum, Hf I; Zeeman effect, Hf I.

The present publication terminates the work on the analysis of Hf I which was started by the late W. F. Meggers in 1928 and left unfinished in 1966. His final line list contains some 4700 lines of which about 67 percent have been classified. Observed g-values are known for 198 levels. The reliability of the Zeeman observations is indicated in tables containing sums of Observed and Landé g-values for selected groups of "even" and "odd" terms.

An attempt has been made to continue Meggers' analysis in LS-coupling as far as possible. This coupling is not rigorous in Hf I, and many intervals are irregular. Consequently, the levels are given also in numerical order with the even and odd levels presented in separate tables.

An ionization limit of 54700 ± 600 cm^{-1}, giving an ionization potential of 6.78 ± 0.07 eV has been derived from a two-member series.

The long line lists are given in two Appendices: Appendix A contains the observed Zeeman data for the individual lines, 531 in all; Appendix B consists of the complete line list of observed and classified lines.

By far the greater part of the analysis is that of Meggers. Detailed notes explain changes that have been introduced and additions to this work.

Monogr. 154. **The dynamics of fields of higher spin,** R. W. Hayward, *Nat. Bur. Stand. (U.S.), Monogr. 154,* 99 pages (Aug. 1976) SD Catalog No. C13.44:154.

Key words: causality; high spin fields; inhomogeneous Lorentz group; relativistic fields; wave equations.

There are several difficulties that plague all existing relativistic equations of motion describing elementary fields having an intrinsic spin greater than one. While the free field equations can be shown to be explicitly covariant, the introduction of interactions gives rise to a phenomenon of noncausality. In the presence of interactions, the retarded solutions spread beyond the light cone and the influence travels faster than light. Furthermore, the solutions in certain simple potentials do not have a finite norm, violating the probabilistic requirements of quantum mechanics.

This paper develops a relativistic theory that is free of the aforementioned difficulties. This Lagrangian theory describes fields and particles with arbitrary mass and charge and having any discrete spin, integer or half integer. Apart from gauge conditions there are no subsidiary conditions.

A matrix formulation is used. The generators of the inhomogeneous Lorentz group for a field of any intrinsic spin and mass are defined in terms of Wigner operators of the group SU(2) and a metric operator. A maximal Abelian set of invariants is formed which defines two completely reducible represen-

tation bases of the inhomogeneous Lorentz group having distinct structures. A set of γ matrices, obeying a Clifford algebra, is also defined in terms of the Wigner operators and the metric operator. State vectors having different structures and Lorentz transformation properties can be related to one another by operators involving the γ matrices.

The equations of motion can be obtained from the Lagrangian by variational methods, and certain aspects of the canonical formalism can be used to quantize the fields. Invariance of the Lagrangian under infinitesimal displacements and rotations yield conservation laws and constants of the motion for pertinent physical observables. The metric of the Hilbert space of the states is uniquely defined for any spin field, assuring positive definite four momenta and charge.

The Dirac formulation for the spin one-half field and the Maxwell-Lorentz formulation for the electromagnetic field are special cases of this theory.

Monogr. 157. **Computers, health records, and citizen rights,** A. F. Westin, *Nat. Bur. Stand. (U.S.), Monogr. 157,* 401 pages (Dec. 1976) SD Catalog No. C13.44:157.

Key words: citizen rights; computers; confidentiality; data systems; health records; information policy; management principles; medical records; privacy; recordkeeping practices; security.

This report investigates the impact of computers on citizen rights in the health recordkeeping area. Under Dr. Alan F. Westin's direction, from July of 1974 to April of 1976, a small interdisciplinary team did the following: (1) examined published literature from medicine and health, law, computing, and social science; (2) conducted interviews with major computer manufacturers, systems developers, health professionals and civil liberties, public interest, consumer, and minority-rights groups; (3) made on-site visits to six representative health-care organizations using computers to handle personal records; (4) corresponded with 70 organizations in the health field; and (5) subjected an initial draft report to review by a conference of experts in September 1975 and subsequently by about 50 outside reviewers. The findings of this investigation were then combined into this four-part report. Part One describes the world of medical data and citizen rights within the framework of three zones—primary health care (by health professionals), service payers and health care reviewers, and social uses of health data (such as in employment, life insurance, and welfare); Part Two treats patterns of computerization in health-care organizations that were studied in depth; and Part Four analyzes the impact of computerization on personal health records, presents comparisons with six other democratic nations, and states 12 recommended management principles for health care data systems. The report also contains a 28 page bibliography and twelve appendices with support documents and information.

3.6. HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

H116. **American National Standard N540; classification of radioactive self-luminous light sources,** *Nat. Bur. Stand. (U.S.), Handb. 116,* 15 pages (Jan. 1976) SD Catalog No. C13.11:116.

Key words: classification; containment; designation; light sources; national standard; radiation source; radioactive; radioluminous products; self-luminous sources; test procedures.

This standard establishes the classification of certain radioactive self-luminous sources according to radionuclide, type of source, activity, and performance requirements. The objectives are to establish minimum prototype testing requirements for radioactive self-luminous light sources, to promote uniformity of marking such sources, and to establish minimum physical performance for such sources. This standard is primarily directed toward assuring adequate containment of the radioactive material. Testing procedures and classification designations are specified for discoloration, temperature, thermal shock, reduced pressure, impact, vibration, and immersion. A range of test requirements is presented according to intended usage and source activity.

H119. **Quieting: A practical guide to noise control,** R. D. Berendt, E. L. R. Corliss, and M. S. Ojalvo, *Nat. Bur. Stand. (U.S.), Handb. 119,* 163 pages (July 1976) SD Catalog No. C13.11:119.

Key words: airborne and structure-borne sounds; aircraft noise intrusion; annoyance; appliance noise; health and hearing hazards; household noise; legal and community action; loudness; noise control and abatement; traffic noise.

This guide offers practical solutions for ordinary noise problems that a person is likely to meet. The discussion describes the ways in which sounds are generated, travel to the listener, and affect his hearing and well-being. Recommendations are given for controlling noise at the source and along its path of travel, and for protecting the listener. The guide instructs the reader by way of "Warning Signs" on how to determine whether he is being subjected in his environment to prolonged noise exposures that may prove hazardous to his hearing. Remedies are given for noise problems that a person is likely to find in his home, at work and at school, while traveling, and in the growth and development of his community. The remedies include noise prevention techniques and selection of quiet alternatives to existing noise sources. General principles for selecting quiet appliances are given. Ways of searching for the sources of noise and for determining the paths over which they travel to the listener are described. A detailed index is given for individual noise sources describing specific solutions to the problems they present. General ways of looking for inherently quiet homes and travel accomodations are described. In a final chapter, there are suggestions for enlisting community help where large external sources of noise must be quieted, such as those arising from public utilities and public transportation.

H120. **Energy management guide for light industry and commerce,** W. J. Kelnhofer and L. A. Wood, *Nat. Bur. Stand. (U.S.), Handb. 120,* 28 pages (Dec. 1976) SD Catalog No. C13.11:120.

Key words: energy conservation; energy conservation guide; energy conservation opportunities; energy conservation program; industrial energy conservation.

The Energy Management Guide for Light Industry and Commerce is a training tool to assist small industrial and commercial organizations in an energy conservation program. It is part of a planned series, starting with NBS HB-115 (EPIC), of guides and training aids to assist industry in making the most efficient use of the energy supply.

While much of the information in the Light Industry Guide has been published in EPIC, the material has been edited and rewritten in shortened form for use by the large number of small organizations with a limited supply of technical manpower. The energy conservation case studies (Cost Saving Opportunities) have been written with this target audience in mind.

3.7. SPECIAL PUBLICATIONS

Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

SP400-15. **Semiconductor measurement technology: ARPA/NBS Standards 1975 catalog. A compilation of abstracts and key word and author indexes,** B. L. Hurdle, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 7,* 595 pages (June 1976) SD Catalog No. C13.10:305 Suppl. 7.

Key words: abstracts; NBS publications; key words; publications.

This supplement to Special Publication 305 Supplements 1 through 6 of the National Bureau of Standards lists the publications of the Bureau issued between January 1, 1975 and December 31, 1975. It includes an abstract of each publication (plus some earlier papers omitted from Special Publication 305 Supplement 6), key-word and author indexes; and general information and instructions about NBS publications.

Miscellaneous Publication 240 (covering the period July 1, 1957 through June 30, 1960) and its supplement (covering the period July 1, 1960 through June 30, 1966), Special Publication 305 (covering the period July 1966 through December 1967), and Special Publication 305 Supplement 1 (covering the period 1968-1969), Special Publication 305 Supplement 2 (covering the period 1970), Special Publication 305 Supplement 3 (covering the period 1971), Special Publication 305 Supplement 4 (covering the period 1972), Special Publication 305 Supplement 5 (covering the period 1973), Special Publication 305 Supplement 6 (covering the period 1974), remain in effect. Two earlier lists, Circular 460 (Publications of the National Bureau of Standards, 1901 to June 1947) and its supplement (Supplementary List of Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957) are also still in effect.

SP384. **Annotated bibliography of the literature on resource sharing computer networks. Revised 1976,** H. M. Wood, S. W. Watkins, and I. W. Cotton, *Nat. Bur. Stand. (U.S.), Spec. Publ. 384 (revised),* 179 pages (Sept. 1976) SD Catalog No. C13.10:384/rev..

Key words: bibliography; computer network; data communications; resource sharing.

This bibliography consists of over 1,000 references with critical annotations to the literature on computer networks. A classification scheme has been developed to make each citation more accessible by general topic. Five indexes to the bibliography are included: author index, corporate author index, network index, title word index, and report number index.

SP386, 1976 Edition. **Standards on noise measurements, rating schemes, and definitions: A compilation,** T. L. Quindry, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 386, 1976 Edition,* 84 pages (Apr. 1976) SD Catalog No. C13.10:386.

Key words: acoustics; noise; rating scheme; sound; standards organization.

This compilation deals with material assembled from the various standards, industrial and trade organizations, or technical and scientific societies concerned with acoustics. There has been no attempt to review or evaluate the standards, but rather just to list documents covering measurement techniques, calibration methods, definitions, rating schemes, and equipment and product specifications concerned with noise. Those standards dealing solely with ultrasonics, audio equipment, or shock and vibration have not generally been included. The paragraphs describing the standards give a brief summary of intent and/or scope of the standard. In some cases the paragraph is the official description of the standard as issued by the organization or society promulgating the standard, while in others the paragraph merely describes the intent of the standard. Proposed standards are also listed where available. Not listed are proposed revisions of current standards and those which must be reapproved to remain in effect. For the convenience of those readers wishing to purchase copies of standards, names and addresses for the various organizations and/or societies are provided. Federal Regulations directly involving noise measurements are given in Appendix A. Appendix B lists active committees for each organization and names and addresses of appropriate committee chairmen or technical contacts. This compilation includes all information available as of January 1, 1976.

SP396-3. **Critical survey of data sources: Corrosion of metals,** R. B. Diegle and W. K. Boyd, *Nat. Bur. Stand. (U.S.), Spec. Publ. 396-3,* 38 pages (Jan. 1976) SD Catalog No. C13.10:396-3.

Key words: commercial alloys; corrosion; data sources; metals.

This survey was undertaken to provide a directory of authoritative sources of information on corrosion of metals. It assesses the scope, assets, and deficiencies of about thirty-eight of the most important sources. These include handbooks and technical compilations, information centers, technical societies, and trade associations and institutes. The initial listing of sources to be included was drafted by the authors and submitted to members of the Publications Committee of the National Association of Corrosion Engineers. This Committee thus served as an ad hoc review group for the sources which appear herein. The Directory is indexed by materials and types of corrosion.

SP396-4. **Critical surveys of data sources: Electrical and magnetic properties of metals,** M. J. Carr, R. B. Gavert, R. L. Moore, H. W. Wawrousek, and J. H. Westbrook, *Nat. Bur. Stand. (U.S.), Spec. Publ. 396-4,* 92 pages (July 1976) SD Catalog No. C13.10:396-4.

Key words: commercial alloys; data sources; electrical properties; magnetic properties; metals.

This survey is intended to provide a directory of authoritative sources of numerical data on the electrical and magnetic properties of metals, with emphasis on commercial alloys. Fifty-nine sources, including handbooks and other publications, information centers, trade associations, and technical societies are described in detail, including information on the properties and materials covered and the criteria used in the selection of data. A few additional related publications are listed with brief descriptions.

SP400-7. **Semiconductor measurement technology: Permanent damage effects of nuclear radiation on the x-band performance of silicon Schottky-barrier microwave mixer diodes,** J. M. Kenney, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-7,* 30 pages (Apr. 1976) SD Catalog No. C13.10:400-7.

Key words: diodes; gamma rays; hardness assurance; microwave mixer diodes; mixers; neutrons; radiation hardness; receivers; Schottky-barrier diodes; semiconductors; solid-state devices; x-band measurements.

The permanent damage induced by nuclear radiation in silicon Schottky-barrier x-band microwave mixer diodes was assessed by subjecting separate groups of diodes to ^{60}Co gamma rays and fast neutrons (E>10 keV) of progressively higher levels, reaching a total gamma dose of 1.7×10^{8} rads (Si) and a cumulative neutron fluence of 5.5×10^{15} cm^{-2}. Measurements were made at a local oscillator frequency of 9375 MHz to determine changes in conversion insertion loss, local oscillator return loss and SWR, i-f output conductance, self-bias, and forward current at one dc bias voltage.

No changes due to the gamma irradiation were observed. At a neutron fluence of 1.0×10^{15} cm^{-2}, changes in conversion insertion loss and forward current were just discernible. At 5.5×10^{15} cm^{-2}, the conversion insertion loss of most diodes was degraded by up to 0.7 dB, although some diodes were unchanged and the average change was only 0.2 dB. The return loss, SWR, and self-bias voltage of most diodes were distinctly altered at this level, and the forward current of all diodes was decreased. The i-f output conductance was not significantly altered.

A group of unirradiated diodes, intermixed with the gamma and neutron groups during measurements, served as a control. Since diode stability was recognized as an important factor, the three groups were matched on the basis of pre-irradiation conversion insertion loss stability. The three-sigma repeatability of the conversion insertion loss measurement was estimated from the control group measurements to be about 0.05 dB, with a systematic drift over the course of these measurements of about the same amount.

SP400-15. **Semiconductor measurement technology: ARPA/NBS workshop III. Test patterns for integrated circuits,** H. A. Schafft, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-15,* 52 pages (Jan. 1976) SD Catalog No. C13.10:400-15.

Key words: data acquisition; data display; integrated circuits; measurement technology; microelectronics; process control; reliability; semiconductors; silicon; test patterns.

Synopses are presented of talks and discussion periods at a meeting on the use and development of MOS and bipolar test patterns and associated data acquisition systems. The discussions revealed that device manufacturers and users are making increased use of test patterns as powerful new measurement tools that can electrically monitor various process parameters to aid in the control of materials, wafer processes, circuit performance, and reliability. However, the large volume of data generated from these test patterns and the requirement for rapid diagnostic feedback present severe challenges in data management and display. In this report several data acquisition systems are described, as are approaches for presenting data in more easily interpretable graphic displays. The need for improvements in the design of test patterns is emphasized. In particular, problems with measuring contact resistance and the properties of oxides, surfaces, and defects, are identified. Numerous test structures are described including charge coupled device structures which can measure some characteristics not easily measured by other means. Also described are NBS's efforts and plans to identify, analyze, and intercompare selected test structures of value to the industry and its customers, and to develop measurement methods for use with these structures.

SP400-18. **Semiconductor measurement technology: The destructive bond pull test,** J. Albers, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-18,* 52 pages (Feb. 1976) SD Catalog No. C13.10:400-18.

Key words: bond angle; bonding; bond pull test; bond-to-bond spacing; large wire; loop height; microelectronics; nondestructive bond pull test; position of hook; pull rate; pull strength; resolution-of-forces; semiconductor devices; ultrasonic bonding; wire bond.

This report summarizes the work done at NBS on the destructive bond pull test as applied to small-diameter (approximately 1 mil or 25 μm) ultrasonically bonded aluminum wire. This work was performed during the period from 1969 to 1974. The report begins with a brief summary of the calculation of the resolution-of-forces operative in the bond system during the application of the pulling force. Next, comparisons of the theoretical and experimental dependencies of the pull strength on the variables involved in the resolution-of-forces calculation are given. Some of the variables which are not directly involved in this calculation are then considered and their effects on the measured pull strength are presented. The report ends with a sensitivity calculation as to how well the variables must be controlled to maintain the variability of the pull strength to within given limits. Bond pull specifications for large-diameter wire as well as recommended force levels to be used in the application of the nondestructive bond pull test, both of which have resulted from the pull test work, are considered in the appendices.

SP400-19. **Semiconductor measurement technology: Progress report, January 1 to June 30, 1975,** W. M. Bullis, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-19,* 95 pages (Apr. 1976) SD Catalog No. 13.10:400-19.

Key words: acoustic emission; beam-lead bonds; bias-temperature stress test; boron redistribution; capacitance-voltage methods; charge-coupled device structures; Darlington pairs; deep depletion; dopant profiles; electrical properties; electron beam induced current; electron beam induced damage; electronics; epitaxial layer thickness; four-probe method; hermeticity; leak tests; measurement methods; microelectronics; moisture infusion; optical flying-spot scanner; oxide films; passivation overcoats; photomask metrology; pull test; resistivity; Rutherford backscattering; scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; shear test; sheet resistors; silicon; silicon on sapphire; spreading resistance; test patterns; thermal resistance; thermal response; transistors; ultrasonic bonding; wire bonds; x-ray photoelectron spectroscopy.

This progress report describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Both in-house and contract efforts are included. The emphasis is on silicon device technologies. Principal accomplishments during this reporting period included (1) completion and analysis of an interlaboratory evaluation of standard reference wafers for resistivity measurement by the four-probe method, (2) analysis of the effect of finite contact size on sheet resistance as measured with a van der Pauw structure, (3) calculation of errors introduced in measuring line width with typical microscope systems, (4) development of procedures for predicting the magnitude of electron beam induced current in silicon device structures, (5) application of the optical flying-spot scanner to observation of hot spots and nonlinearities in rf power transistors and of logic patterns in an MOS shift register, and (6) determination of a more accurate electrical method, based on peak junction temperature measurement, for establishing safe operating area curves for medium power transistors. Also reported are the results of work on spreading

resistance measurements, ionization of dopant impurities in silicon, Rutherford backscattering measurements, x-ray photoelectron spectroscopy, ion microprobe mass analysis, tests for determining the surface quality of sapphire substrates, reevaluation of Irvin's curves, mathematical models of dopant profiles, deep depletion measurements of resistivity profiles, measurement of epitaxial layer thickness by the deep depletion method, bias-temperature stress test measurements on MOS capacitors, a high voltage capacitance-voltage method for measuring characteristics of thick insulator films, ion implantation parameters, methods for determining integrity of passivation overcoats, optical imaging and calibration standards for photomask metrology, line-width measurements, charge-coupled device test structures, test pattern design and analysis for silicon on sapphire MOS device technologies, nondestructive acoustic emission test for beam-lead bonds, pull and shear tests for wire bonds, a rapid cycle dry gas gross leak test, leak detection by helium mass spectrometry, correlation of moisture infusion in semiconductor packages with leak size and device reliability, an automated scanning low-energy electron probe, electron beam induced damage in silicon device structures, and thermal resistance measurements on Darlington transistors. Supplementary data concerning staff, publications, workshops and symposia, standards committee activities, and technical services are also included as appendices. A sixth appendix is included to summarize the results of a study which was carried out to assess the impact of automation of integrated circuit processing and assembly on future measurement requirements in the industry.

SP400-21. **Semiconductor measurement technology: Planar test structures for characterizing impurities in silicon,** M. G. Buehler, J. M. David, R. L. Mattis, W. E. Phillips, and W. R. Thurber, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-21,* 32 pages (Jan. 1976) SD Catalog No. C13.10:400-21.

Key words: MOS capacitors; *p-n* junctions; resistivity of silicon; semiconductor devices; semiconductor process control; sheet resistors; test patterns; thermally stimulated currents.

Various test structures such as sheet resistors, *p-n* junctions, and MOS capacitors and their associated physical models have been developed to characterize dopants and defects in silicon. These structures address various needs within the semiconductor industry for (a) well-designed and miniaturized test structures such as an orthogonal van der Pauw sheet resistor, (b) simple and economical measurements such as the oxide window width of a diffused layer, (c) updated values for the resistivity versus dopant density relation, and (d) improved detection methods for identifying defect centers which control the lifetime and leakage currents of devices.

SP400-22. **Semiconductor measurement technology: Microelectronic test pattern NBS-3 for evaluating the resistivity-dopant density relationship of silicon,** M. G. Buehler, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-22,* 57 pages (June 1976) SD Catalog No. C13.10:400-22.

Key words: dopant density; microelectronics; MOS capacitors; *n-p-n* transistor fabrication; *p-n* junctions; resistivity; semiconductor electronics; sheet resistors; silicon; test pattern; test structures.

Test pattern NBS-3 is a microelectronic test vehicle designed by the National Bureau of Standards to evaluate the electronic materials used in discrete semiconductor devices and integrated circuits. Designed for fabrication on silicon wafers, the test pattern is an aid in better understanding integrated circuit fabrication technologies. The main pattern consists of four masks designated BASE, EMITTER, CONTACT, and METAL and contains 33 test structures such as sheet resistors, MOS capacitors, *p-n* junctions, bipolar and MOS transistors, and etch control and resolution structures.

The pattern was designed primarily to aid in the evaluation of the relationship between resistivity and dopant density in both *n*- and *p*-type silicon. This relation is needed in the design of silicon solid-state devices and in the analysis of various physical measurements. Other test structures are included for use as diagnostic tools to verify that proper fabrication procedures were followed. The remaining structures allow the exploration of new designs and measurement methods.

The structures are arranged in a square pattern 200 mil (5.08 mm) on a side. A detailed layout of each test structure is presented including both a top view and a cross sectional view. A description of each structure is given and where applicable the formulas for evaluating such quantities as resistivity, dopant density, and sheet resistance are given. The fabrication of the test pattern is illustrated by an *n-p-n* transistor process and values obtained from various test structures are presented.

SP400-23. **Semiconductor measurement technology: ARPA/NBS Workshop IV. Surface analysis for silicon devices,** A. G. Lieberman, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-23,* 238 pages (Mar. 1976) SD Catalog No. C13.10:400-23.

Key words: Auger spectroscopy; depth profiles; electron beam induced imaging; ESCA; insulator films; interface characteristics; internal photoemission; ion scattering spectroscopy; nuclear resonance profiling; photodepopulation; photovoltaic imaging; Rutherford backscattering; SCANIIR; secondary ion mass spectroscopy; semiconductor devices; silicon; surface analysis; x-ray photoelectron spectroscopy.

This report contains the proceedings of the ARPA/NBS Workshop IV, *Surface Analysis for Silicon Devices,* held at the National Bureau of Standards on April 23-24, 1975.

The Workshop, as part of an NBS program to develop measurement technology for the field of semiconductor devices, was held to discuss the present capabilities and future prospects of modern analytical beam techniques as applied to silicon, and associated insulator films and device structures. Of particular interest were the determination of impurity profiles, surface contamination, and interface characteristics. Techniques utilizing impinging electron, ion, neutral or photon beams were considered. The Workshop was directed at the analysts, the semiconductor manufacturers who use the analysts' results, and the instrument people who design and manufacture the analytical equipment. Transcripts of the discussions following each paper are also included within these proceedings. *These proceedings include the following papers (indented):*

Introductory concepts for silicon surface analysis, A. G. Lieberman, *SP400-23,* pp. 3-6 (Mar. 1976).

Identification of integrated circuit process areas amenable to diagnosis and control by analytical beam techniques, B. E. Deal, *SP400-23,* pp. 7-20 (Mar. 1976).

Low energy ion scattering spectrometry studies of Si, SiO_2 and related materials, W. L. Harrington, *SP400-23,* pp. 21-30 (Mar. 1976).

Surface analysis by secondary ion mass spectroscopy techniques, R. D. Dobrott, *SP400-23,* pp. 31-43 (Mar. 1976).

Some effects limiting SIMS depth profile analysis and methods for improvement, R. K. Lewis, *SP400-23,* pp. 45-59 (Mar. 1976).

Qualitative assessment of ion erosion damage by means of electron channeling patterns, D. E. Newbury, *SP400-23,* pp. 61-63 (Mar. 1976).

The effect of specimen cooling on the migration of sodium in thin film SiO_2, B. F. Phillips, A. E. Austin, and H. L. Hughes, *SP400-23,* pp. 65-72 (Mar. 1976).

Silicon-on-sapphire impurity analysis, D. W. Phillips, *SP400-23,* pp. 73-79 (Mar. 1976).

Surface composition by analysis of impact radiation, C. W. White, *SP400-23,* pp. 81-84 (Mar. 1976).

Nuclear resonance and backscattering surface analysis of silicon and related insulators, K. L. Dunning, *SP400-23,* pp. 95-104 (Mar. 1976).

Applications of scanning Auger spectroscopy (SAM) to the silicon integrated circuit (SIC) technology, J. M. Morabito, *SP400-23,* pp. 105-118 (Mar. 1976).

Use of Auger electron spectroscopy to determine the structure of silicon oxide films, J. S. Johannessen, W. E. Spicer, and Y. E. Strausser, *SP400-23,* pp. 119-123 (Mar. 1976).

An Auger electron spectroscopy study of silicon spectra from silicon monoxide, silicon dioxide and silicon nitride, Y. E. Strausser and J. S. Johannessen, *SP400-23,* pp. 125-138 (Mar. 1976).

Surface compositional changes with electron bombardment observed by AES, S. Thomas, *SP400-23,* pp. 139-141 (Mar. 1976).

Combined scanning electron microscopy—Auger spectroscopy for micro-spot surface and in-depth analysis of silicon and transistor metallizations, A. Christou, W. Weisenberger, and H. M. Day, *SP400-23,* pp. 143-150 (Mar. 1976).

Applications of x-ray photoelectron spectroscopy (ESCA) to MIS devices, F. J. Grunthaner, *SP400-23,* pp. 151-173 (Mar. 1976).

Choosing between ESCA and Auger for surface analysis, G. E. McGuire, *SP400-23,* pp. 175-182 (Mar. 1976).

Silicon device applications using a combined ESCA/AES analysis system, L. E. Davis and G. E. Riach, *SP400-23,* pp. 183-187 (Mar. 1976).

Photodepopulation technique for the study of electronic traps in insulators, T. H. DiStefano and J. M. Franz, *SP400-23,* pp. 189-195 (Mar. 1976).

Photoemission and photovoltaic imaging of semiconductor surfaces, T. H. DiStefano, *SP400-23,* pp. 197-209 (Mar. 1976).

Electron beam induced imaging of silicon surfaces, W. R. Bottoms, *SP400-23,* pp. 211-218 (Mar. 1976).

A comparison of the techniques for silicon surface analysis, C. A. Evans, Jr., *SP400-23,* pp. 219-232 (Mar. 1976).

SP400-25. **Semiconductor measurement technology. Progress Report, July 1 to December 31, 1975,** W. M. Bullis, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-25,* 87 pages (Oct. 1976) SD Catalog No. C13.10:400-25.

Key words: acoustic emission; Auger electron spectroscopy; beam-lead bonds; bias-temperature stress test; boron redistribution; capacitance-voltage methods; dopant profiles; electrical properties; electronics; four-probe method; hermeticity; interface states; ion implantation; ion microprobe mass analysis; leak tests; measurement methods; microelectronics; moisture infusion; optical flying-spot scanner; passivation overcoats; photoresist; pull test; resistivity; scanning acoustic microscope; scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; silicon on sapphire; spreading resistance; test patterns; thermally stimulated current; thermal resistance; ultrasonic wire bonding; voltage contrast mode; x-ray photoelectron spectroscopy.

This progress report describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Both in-house and contract efforts are included. The emphasis is on silicon device technologies. Principal accomplishments during this reporting period included (1) preliminary results of a systematic study of the effects of surface preparation on spreading resistance measurements; (2) development of an optical test for surface quality of sapphire; (3) development of a basis for an exposure sensitivity specification for photoresists; and (4) development of a modular cell concept for test structure design and layout. Also reported are the results of work on four-probe resistivity measurements, comparison of techniques for surface analysis, ion microprobe mass analysis, analysis of process chemicals with flame emission spectrometry, redistribution profiles, thermally stimulated current response of interface states, bias-temperature stress test measurements on MOS capacitors, a high voltage capacitance-voltage method for measuring characteristics of thick insulator films, hydrogen chloride oxidation, ion implantation parameters, methods for determining integrity of passivation overcoats, measurement of free sodium in an oxidation furnace by resonance fluorescence, a square array collector resistor test structure, an electrical alignment test structure, two dimensional wafer maps, test pattern design and analysis for silicon-on-sapphire MOS device technologies, a nondestructive acoustic emission test for beam-lead bonds, wire bond pull test, bondability of doped aluminum metallizations, leakage into double hermetic enclosures, a static expansion dry gas gross leak test, correlation of moisture infusion in semiconductor packages with leak size and device reliability, an automated scanning low-energy electron probe, an optical flying-spot scanner, scanning electron microscopy, scanning acoustic microscopy, and thermal resistance measurements on power transistors and simple integrated circuits. Supplementary data concerning staff, publications, workshops and symposia, standards committee activities, and technical services are also included as appendices.

SP400-26. **Semiconductor measurement technology: Defects in PN junctions and MOS capacitors observed using thermally stimulated current and capacitance measurements—videotape script,** M. G. Buehler, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-26,* 20 pages (Apr. 1976) SD Catalog No. C13.10:400-26.

Key words: cryostat; defects; gold-doped silicon; measurement methods; microelectronics; MOS capacitor; *p-n* junctions; semiconductors; silicon; thermally stimulated capacitance; thermally stimulated current.

Two measurement methods are described which detect and characterize defects which can control such device characteristics as lifetime and junction leakage. The methods can be used as diagnostic tools in the fabrication of bipolar and MOS devices. The number of different kinds of defects and their densities may be obtained with little effort and simple apparatus. Positive identification of these defects may be obtained with more ef-

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fort and more sophisticated apparatus. Of more importance, the measurements characterize defects in an environment which is identical to that of the finished product. Thus, the answers derived are directly applicable to process control and device design.

These methods involve thermally stimulated capacitance and current measurements which utilize the ability of defects in the vicinity of a p-n junction or in a MOS capacitor to trap holes or electrons and emit them after receiving sufficient thermal energy. Values for defect densities, energy levels, and emission rates can be derived from these measurements. The limit of detectability can be as low as 10^{10} defects/cm^3. These values provide sufficient information to positively identify the defects.

Three vehicles are used to illustrate the methods: a gold doped n^+-p diode, a p^+-n diode with a process-induced defect center, and a gold doped n-type MOS capacitor. Two cryostats are described which have a maximum heating rate of 10 K/s.

SP400-27. **Semiconductor measurement technology: Laser scanning of active semiconductor devices—Videotape script,** D. E. Sawyer and D. W. Berning, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-27,* 26 pages (Feb. 1976) SD Catalog No. C13.10:400-27.

Key words: failure analysis; hot spots; integrated circuits; laser scanner; measurement method; nondestructive test; nonlinear operation; optical scanner; reliability; transistors.

This is the script of a videotape presentation which describes new and powerful applications for laser scanning in semiconductor device design and reliability work. The design of the scanner is described in detail and many of its applications are displayed and discussed. The optical scanner can, in a completely nondestructive way, reveal the inner workings of semiconductor devices. For example, it is shown that the scanner can (1) map dc and high-frequency gains in transistors, (2) reveal areas of the device operating in a nonlinear manner, (3) electronically map temperature in the transistor, and (4) detect the location of hot spots that can develop for certain operating conditions. The vehicle used to show these capabilities of the scanner is a bipolar interdigitated UHF transistor. A dual input NAND gate is used to demonstrate the use of the scanner to determine internal logic states and otherwise observe internal operation of the circuit. To show the ability of the scanner to examine MOS devices without detectable degradation, a MOS shift register is used. The location and progress of internal logic in the register is clearly shown by the scanner. Not only can internal logic be mapped and marginally-operating logic cells detected, but individual logic states can be changed by the scanner without affecting other elements.

SP400-28. **Semiconductor measurement technology: NBS/FDA workshop. Reliability technology for cardiac pacemakers,** H. A. Schafft, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-28,* 49 pages (June 1976) SD Catalog No. C13.10:400-28.

Key words: cardiac pacemaker; data banks; failure analysis; failure modes; hermeticity; hybrid devices; leak testing; measurement technology; microelectronics; MOS devices; process control; reliability; semiconductor devices; surgical implants.

Brief summaries are presented of 20 invited talks on the following topics: procurement and assurance of reliable, long lived semiconductor electronic parts; leak testing of device packages and pacemaker systems; activities of standardization organizations; and availability and use of resources for information and expertise. The purpose of the workshop was to address technical questions relevant to the enhancement and assurance of cardiac pacemaker reliability, and to bring together representatives from the pacemaker, military, aerospace, and other communities to discuss areas of mutual concern. The technical sessions highlighted the problems of pacemaker manufacturers associated with obtaining high reliability electronic components—problems shared with the most demanding users in the military and space communities. It was also noted that no government agency has the authority or responsibility for the development of methods to permit assured procurement of high quality electronic components for critical applications by organizations in the civilian sector. These organizations must rely on spin-off from military and space programs even when parts of this civilian sector have reliability requirements which are more severe than all but the most stringent military and space requirements. Included in appendices are measurement technology areas of concern identified by the pacemaker community; information about utilizing reliability data banks and facilities for searching literature and data; and organizations offering services in the microelectronics field.

SP400-34. **Semiconductor measurement technology: Safe operation of capacitance meters using high applied-bias voltage,** A. M. Goodman, *Nat. Bur. Stand. (U.S.), Spec. Publ. 400-34,* 57 pages (Dec. 1976) SD Catalog No. C13.10:400-34.

Key words: bias-isolation unit; capacitance measurements at high applied-bias voltage; capacitance-meter; extended-range capacitance measurement; high-voltage C(V) measurements; modified MIS C(V) measurements.

The use of capacitance meters (C-meters) to determine small-signal (differential) capacitance at 1 MHz as a function of applied-bias voltage is widespread. The maximum value of the bias voltage which may be applied to a sample under test with any commercially available C-meter is 600 V or less. A larger bias-voltage capability is required for certain applications.

This report describes a technique for using a commercial C-meter with a Bias-Isolation Unit (BIU) for capacitance measurements at bias-voltage magnitudes up to 10 kV without damage to the measurement equipment. The basic principles of operation and the details of the electrical design of a BIU are discussed.

The use of the BIU imposes certain limitations on the range of sample capacitance which may be measured without introducing excessive error. The theory of these limitations is presented and compared with experimental results obtained from the use of the BIU with each of three commercially available C-meters. The measurement capability demonstrated by these results appears to be adequate for all current and future applications. For less than ± 1 percent error in the indicated (measured) capacitance, the measurable range of the sample capacitance is found to be from 0 to at least 400 pF. In some applications, it is important to be able to accurately measure small changes in the sample capacitance; for less than ± 1 percent error in the indicated (measured) value of a small change in the sample capacitance, the measurable range of the sample capacitance is found to be from 0 to at least 130 pF.

Construction details of the BIU are appended.

SP403. **Energy conservation through effective energy utilization.** 1973 Engineering Foundation Conference, New England College, Henniker, NH, Aug. 19-24, 1973, J. C. Denton, S. Webber, and J. Moriarty, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 403,* 251 pages (June 1976) SD Catalog No. C13.10:403.

Key words: automobile; break-even analysis; conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics.

These proceedings of the 1973 Engineering Foundation Conference focus on effective utilization of thermal energy as a means of energy conservation. It is hoped publication will help stimulate the national dialogue toward a balanced national program for more energy conservation.

The varied professional backgrounds of the participants provided an interdisciplinary approach for action steps to be taken in areas where research is needed and will provide a significant impact. For example, the development of better stack controls was recommended as a specific research task, and the improvement of energy accounting systems and energy use norms was recommended as a useful research area. Broad agreement was reached that there is much left to be accomplished in thermal process technology as used in industrial processes, in industrial equipment, and in heating, ventilating, and air conditioning (HVAC) equipment for buildings.

A clear conclusion of the conference is that while new technology is important the introduction of much technology that is already available is equally, if not more, important. Institutional barriers relating to economics, management, finance, and national policy keep available technology standing in the wings. The conference papers and discussions show that engineering design, when it can be rigorously applied, does result in striking reductions in energy use in the thermal process technologies. *These proceedings include the following papers (indented):*

Effective utilization of energy and other natural resources, C. A. Berg, *SP403*, pp. 3-12 (June 1976).

Key words: costs; economics; energy; fuel; imports.

An overview of the Nation's energy problems is presented to provide a basis of definition for the term "energy crisis." The term does not represent a crisis of depletion of energy resources but rather refers to energy cost. The dependency of the United States on fuel imports illustrates the problems that questionable reliability and increasing costs of fuel imports pose for American industry. Improving energy use efficiency would reduce energy consumption and, considering rising energy costs, may prove to be economically attractive to industry. A policy of national life-term costing of equipment, which includes energy cost of that equipment, should be promoted rather than the present criterion of justification which is based primarily on first costs. Further, a rational economic method for achieving effective and balanced use of all natural resources, based on total life-term costing, is advocated.

Energy conservation goals and methods, R. E. Shepherd, *SP403*, pp. 13-18 (June 1976).

Key words: conservation; energy; organization.

The goals of the President's energy message of early 1973 and the feasibility of the 1974 goal of a 5 percent energy use reduction nationally are discussed. An overview of the Federal government's organizational structure is presented and discussed with reference to attaining these goals. Voluntary energy conservation measures and a major educational program directed at energy users are urged to help solve the Nation's energy problems.

National benefits of energy conservation, L. R. Glicksman and D. C. White, *SP403*, pp. 21-41 (June 1976).

Key words: correlation; economic; energy; imports; international; petroleum.

Starting from the correlation between a nation's gross national product and its energy consumption per capita, the consequences of economic growth on the world's estimated energy resources is discussed. In the absence of new energy technologies or a reduction of energy consumption in relationship to GNP, sustained high economic growth will be difficult and costly to achieve as our own resource base diminishes. The developing nations of the world will be competing for resources as their own GNP's increase, further exacerbating the resource depletion problem. As the nations of the world compete for scarce resources, there are potential international complications beyond those presently apparent in the effect of petroleum imports on America's transportation sector.

Options for energy conservation, B. Hannon, *SP403*, pp. 43-56 (June 1976).

Key words: economic; energy; input-output model.

An input-output model useful in measuring energy use, efficiency of production processes, and product uses is presented. The model provides estimates of total energy and employment shifts in a variety of processes and products. Several of these demand shifts and their potential impacts are discussed. United States industry, in general, becomes more energy-intensive as it grows. The impacts of demand shifts and changing character of industry as it evolves on consumer cost, employment, and pollution should be thoroughly understood before policy recommendations should be initiated.

Measures of thermal energy utilization, B. B. Hamel and H. L. Brown, *SP403*, pp. 57-64 (June 1976).

Key words: energy; heating systems; model; thermodynamics.

It is necessary to quantify, or structure, the ideas of thermal energy utilization in order to develop an efficiency of energy utilization. Such a quantitative analysis is useful in assessing any modification or change in design of an energy system. A method of analysis useful in assessing modifications in an energy system is presented. The concept of thermodynamic availability is used to determine maximum energy utilization efficiency. The method is illustrated by evaluating the efficiencies of several water heating systems.

Economic and environmental implications of effective utilization of energy, J. C. Denton, *SP403*, pp. 65-74 (June 1976).

Key words: automobile; economic; energy; model; transform analysis.

Technology uses energy, materials, money, people, etc. to produce products and services for society. The resultant products and their impacts on resources, society and the environment exist in a dynamic interrelationship. Technology transform analysis is an analytical model which is proposed to identify and elucidate the interrelationships between these elements and to assess the consequences of their modification. The technology transform analysis is prerequisite to the application of input-output analysis if the interrelationships between energy, environmental, economic, and human factors is to be displayed in a compatible fashion. An abbreviated example analysis of the automobile industry is presented to demonstrate the complexities which must be included and the subtleties which appear. Possible pitfalls of an incomplete analysis are discussed.

Industrial energy analysis and forecasting, D. R. Limaye, J. R. Sharko, and J. H. Kayser, *SP403*, pp. 77-93 (June 1976).

Key words: break-even analysis; economics; energy; industrial.

Although the industrial sector is one of the largest consumers of energy (over 33% of total energy consumption), relatively little is known in detail about the end use characteristics in this sector because of the diversity of processes and practices. Two approaches are discussed: a detailed engineering process analysis, involving an in-depth look at each major product in each industry; and a survey approach employing interviews and questionnaires. Studies are presented on the Chemical and Allied Products industry (SIC 28). A break-even analysis is employed to determine the prices at which two fuels are economically equivalent. An overall methodology is presented for integrating all of the different aspects of industrial energy analysis. The initial steps are the identification of end use characteristics, energy requirements per unit of output, process economics, and qualitative factors affecting energy use. Based on these and on estimates of total industrial output, the total energy requirements can be determined.

Management's role in industrial thermal energy utilization, A. S. Cook, *SP403*, pp. 95-101 (June 1976).

Key words: conservation; costs; economics; energy; thermal.

The industrial sector has a vital role and stake in decisions with respect to utilization of the country's thermal energy resources. Energy management responsibility requires a significant reorientation of the management job toward energy conservation. Industrial management's present dedication is to competitive free enterprise and energy substitution for human toil. The reorientation is toward acceptance of higher energy costs and toward security of energy supply. Discussions are presented on what industrial manufacturing can do and some factors external to industrial process thermal energy utilization. In the former category a new process technology, ultraviolet curing, is presented to exemplify conservation results from application of a new technology. In the latter category, it is emphasized that a given company cannot operate in isolation in its energy conservation efforts without running the risk that the total energy required by the society may increase.

Development of industrial energy management policies, M. C. Noland, *SP403*, pp. 103-111 (June 1976).

Key words: conservation; economic; energy; management; manufacturing.

A systematic approach to energy management at the operational level must be custom-fitted to specific industrial facilities. Preliminary results of attempts to (1) determine the steps being taken by industry in response to changing energy supply conditions and the potential for conservation inherent in that response and (2) develop guidelines for the establishment of plant energy management policies in the manufacturing and process industries are presented. The major incentive for future conservation of energy by industry is cost. The only alternative is regulation and enforcement. The economic incentive involves both direct energy cost and the indirect costs of energy security. The approach to energy problems taken by different firms follows no discernibly systematic pattern, varying from little concern to progressive programs. An outline of steps in the development of industrial energy management policies is presented.

Case histories of effective energy utilization in industry, W. Rudoy, *SP403*, pp. 113-117 (June 1976).

Key words: attitudes; conservation; energy; industrial; systems.

Energy conservation through effective energy utilization falls into three classes: better "housekeeping" or energy management of present systems; application of present off-the-shelf technology to existing systems; and revision of existing systems to provide the same objective with less energy. Three general components enter into any implementation of energy conservation—technology, economics, and people. There is a great deal of off-the-shelf technology that could be employed and case studies are presented showing significant gains in energy conservation in the area of comfort conditioning of the industrial environment. In most cases, the rule-of-thumb economic payback period of two years for revising a system is not met. The decision to move toward more efficient utilization, even when the other two components are favorable, is often influenced by the attitudes of key personnel.

A projection of energy demand by the iron and steel industry, D. Larson, *SP403*, pp. 121-152 (June 1976).

Key words: energy; forecast; industry; iron; steel.

The iron and steel industry is not only one of the larger consumers of energy (7.5% of the total U.S. energy use in 1968), but is also a very complex industry. The interrelationships between projected demand for products and the amounts of fuels needed for manufacturing the products are discussed as well as the trends that could change the amounts of fuels needed per unit of product. Conclusions drawn are that there should be a 65 percent increase in production and a 28 percent increase in energy consumption in the industry between 1971 and 1985. The growth rate of energy consumption decreases with time and should almost level off by 1985. The change in energy requirements per ton of finished product is primarily the result of technological changes. Therefore, trends that phase out obsolete inefficient equipment can accelerate this energy utilization efficiency. Most of the improved efficiency is expected in the iron-making and steel-making processes and very little change is forecast in the reheating and finishing portion of the industry.

Potential energy savings in the forming of paper, T. Speidel and D. Kallmes, *SP403*, pp. 153-161 (June 1976).

Key words: energy; industrial; paper.

The United States produced 59 million tons of paper and paper products in 1972 requiring 320×10^{12} BTU exclusive of the energy required to produce the necessary wood pulp. The conventional paper forming process is described in brief. A new method of forming paper is described having the potential of saving 40 percent of the energy conventionally required to form paper. The new method can make high quality paper utilizing up to 2 percent suspended wood pulp. A helical mixer with a high shear component in the jet permits a 35 percent decrease in the heat required during the process. This process is particularly attractive where fuel oil or fuel gas is used to supply the heat rather than waste bark and black liquor.

Potential for energy conservation in heating, ventilating, and air-conditioning equipment for buildings, G. Kelly, T. Kusuda, and J. Hill, *SP403*, pp. 163-191 (June 1976).

Key words: conservation; cooling; cost; energy; heating.

Approximately one-third of the Nation's energy use is presently used in residential and commercial buildings. Over seventy percent of the energy is being used for heating, cooling, and providing hot water. The potential for energy con-

servation through proper design and use of heating, ventilating, and air conditioning equipment within or in the proximity of buildings is discussed. The topics presented include a discussion of the positive and negative features of both unitary and central HVAC equipment, a description of typical all-air and air-water HVAC systems, the heat pump and how it can be combined with other equipment to conserve energy, and the recovery of energy from the building exhaust air. A brief description is given of total energy systems, modular integrated utility systems, and the utilization of waste heat from incineration plants. Considerable savings could be obtained from judicious choice of standard equipment based on energy conservation considerations. The use of life cycle costing rather than lowest possible first cost would vastly upgrade the present standards of practice.

ASHRAE and energy conservation, P. E. McNall, Jr., *SP403,* pp. 193-195 (June 1976).

Key words: energy; environment; food.

ASHRAE is concerned with all aspects of environmental control for people, as well as for plants and animals as the latter relate to food production and processing. The ASHRAE Guide is discussed and its excellent treatment on thermal comfort in buildings is emphasized. The need for better energy management and the importance of first cost to the building industry in speculative type investments is discussed. The utility of reheat HVAC systems is emphasized since they are easy to maintain and have low initial costs. ASHRAE has considerable know-how which is not optimally used at present because of inadequate incentive. Labor is no substitute for energy since a man is worth only 10 per day in energy expended.

Factors controlling the manufacture and marketing of energy conserving products, J. B. Comly and C. M. Huggins, *SP403,* pp. 199-213 (June 1976).

Key words: costs; energy; heating; manufacturing; marketing.

The complex of factors relating to decisions to manufacture and market new or improved products is discussed, with examples taken from consumer equipment of importance in conservation of energy at the point of utilization. The heat pump and the incandescent light bulb are used as specific examples. Premature marketing of the heat pump as a heating system impaired its degree of acceptance. The tradeoff between energy efficiency and replacement cost of the incandescent light bulb illustrates the optimization of these two factors in a product. Technological development alone does not assure immediate implementation of energy efficient systems. The prospect of commercial success of a product should be evaluated well before that product is brought to market.

Economic, energy, environment trade-offs, P. Swatek, *SP403,* pp. 215-223 (June 1976).

Key words: costs; economics; energy; environment.

The individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in the community but his ethics prompt him also to cooperate. Believing that pecuniary motivation is high on the list of human priorities, freer market mechanisms than presently exist are urged. The market should be unshackled, both removing subsidies to the energy industry (oil depletion allowance) and having the producers internalize the now externalized social and environmental cost of their operations. Such measures are projected to be effective in all energy consuming sectors, await the development of no new technologies, require no legislation of rigid criteria and technical standards, require no bureaucracy, rely on the normal operation of the free market, do not depend on changes in basic motivation of consumers, and will work and produce an efficient allocation of resources.

Regulatory, legal, and tax constraints on energy conservation—Polemic or fact?, C. Warren, *SP403,* pp. 225-235 (June 1976).

Key words: energy; legal; regulatory; standards.

Recognizing the vital role of power in society, an education and voluntary basis for balancing the different mechanisms in the market (such as the adjustment of electric rate structures) is urged. In the last analysis, if this approach is unsuccessful, regulation will be required drawing upon the power of the State. Regulatory enactments should be directed toward behavioral norms in the every day activities of people rather than adjudicating conflicts. The State would set standards for the building industry, controlling lighting and insulation, be prepared to establish allocations of energy, and prescribe levels of operating efficiency. Since the standards proposed are essentially performance criteria rather than product quality criteria, one could enforce conformity at the point of end use.

Financial feasibility of energy conservation, S. Sixfin, *SP403,* pp. 237-241 (June 1976).

Key words: costs; energy; financial; resources; risk.

Energy availability is approached from a purely economic point of view. The technology to be used is determined by the rate of return on the investment. A sample cost feasibility analysis for a 100,000 square foot industrial plant is presented as an example. Besides price, the ultimate criterion for choosing an energy source is its availability. Where critical energy shortages are foreseen, incentives must be provided to encourage the flow of capital in the directions necessary to alleviate the shortages. Private investors should be compensated for the risk that they undertake in the location and development of energy resources.

National context for energy conservation, J. C. Denton, *SP403,* pp. 245-246 (June 1976).

Energy management in industry, R. G. Gatts, *SP403,* pp. 247-250 (June 1976).

Application of thermal process technology, K. G. Kreider, *SP403,* pp. 251-252 (June 1976).

Institutional considerations respecting energy conservation, S. Z. Klausner, *SP403,* pp. 253-254 (June 1976).

SP413, 1976 Edition. **Special technical facilities at the National Bureau of Standards,** H. L. Mason and I. M. Lloyd, Eds., (Supersedes NBS Special Publication 413, 1975 Edition), *Nat. Bur. Stand. (U.S.), Spec. Publ. 413, 1976 Edition,* 50 pages (Mar. 1976) SD Catalog No. C13.10:413/1976 Ed..

Key words: accelerators; acoustic facilities; calorimeters; electrical measurements facilities; high pressure facilities; high temperature facilities; spectroscopy facilities.

Among the major technical facilities of the NBS laboratories in Gaithersburg, Md., and Boulder, Colo., are some which are unique and many which feature equipment that is relatively uncommon. These important resources deserve to be more widely

known and used by the scientific and engineering community, including the Bureau's own staff, other Government agencies, industrial research associates, academic researchers, and postdoctoral fellows. Those facilities which are available for shared use, either occasional or extended, are briefly described in the pages of this publication.

SP416, 1976 Edition. **Attacking the fire problem: A plan for action—1976 Edition,** F. B. Clarke and D. W. Raisher, Eds., (Supersedes NBS Special Publication 416, 1975 Edition) *Nat. Bur. Stand. (U.S.), Spec. Publ. 416, 1976 Edition,* 41 pages (Jan. 1976) SD Catalog No. C13.10:416, 1976 Ed., $1.00.

Key words: building design; consumer protection; fire control; fire detection; fire research; fire spread; flammability.

The mission of the Center for Fire Research is to insure the development of the technical base for the standards and specifications needed in support of the National goal to reduce fire losses by 50 percent over the next generation. A systems approach to accomplish this mission is described. The Center consists of four basic programs in the area of Fire Science and five applied research programs in the area of Fire Safety Engineering. Each applied program addresses an aspect of the Fire Problem, using fundamental information supplied by the basic research function. Active participation by staff members in voluntary standards organizations is the principal means of making this technology available for codes and standards needed to reduce the Nation's fire loss.

SP422. Volume I and II. **Accuracy in trace analysis: Sampling, sample handling, analysis.** Proceedings of the 7th Materials Research Symposium held at the National Bureau of Standards, Gaithersburg, MD, Oct. 7-11, 1974, P. D. LaFleur, Ed., *Nat. Bur. Stand. (U.S.), Spec. Pub. 422, Vol. I,* 645 pages, *Vol. II,* 636 pages, (Aug. 1976) SD Catalog No. C13.10:422/vol. I and II, $20 per 2-part set.

Key words: accuracy; analysis; analytical chemistry; sample handling; sampling; trace analysis.

This book is the formal report of the proceedings of the 7th Materials Research Symposium: Accuracy in Trace Analysis. This volume contains the invited and contributed papers presented at the Symposium, and which treat problems of sampling and sample handling as well as the usually-discussed analytical methodology. Many important techniques and methods are described, and extensive references are presented, to give deeper insight into the problems of obtaining accurate results in trace analytical chemistry. Accordingly, this volume should not only stimulate greater interest in research in these areas but should provide a valuable guide for everyday analytical problems. *These proceedings include the following papers (indented):*

The need for accuracy in a regulatory agency, A. C. Kolbye, Jr., *SP422,* pp. 3-8 (Aug. 1976).

Key words: accuracy; drugs; foods; regulation; regulatory agency.

A discussion of the need for accuracy in the food and drug industries is presented. Problems involved in sampling, sample handling, and methods of analysis are discussed as well as the establishing of permissible limits of contaminants and additives.

Accuracy and trace organic analyses, R. G. Lewis, *SP422,* pp. 9-34 (Aug. 1976).

Key words: concentration; detectors; extraction; gas chromatography; isolation and clean-up; mass spectrometry; organic trace analysis; qualitative accuracy; quality control; quantitative accuracy; reference materials; sampling.

Accuracy in trace organic analysis presents a formidable problem to the residue chemist. He is confronted with the analysis of a large number and variety of compounds present in a multiplicity of substrates at levels as low as parts-per-trillion. At these levels, collection, isolation, identification and quantification are all very difficult. Sample contamination and substrate interferences can also lead to large errors. Obtaining accurate qualitative data is often more of a problem than accuracy of quantitative data. Retention times and peak height measurements from gas chromatography coupled with highly sensitive, but nonspecific, detectors are most commonly used in residue analysis. Although dual column and/or dual detector determination, partition values and chemical derivatization are often employed, lack of good reference standards, interferences and poor detector specificity frequently cast doubt on the qualitative and quantitative accuracy of data upon which regulatory decisions may be made. Mass spectrometry and Fourier transform spectrophotometry offer partial solutions to qualitative accuracy where this instrumentation is available. However, less expensive and more sensitive specific detectors for gas chromatography are most needed. Means of quantitating residues from such complex industrial mixtures as polychlorobiphenyls and toxaphenes are far from adequate. Finally, collection systems for environmental media often lack efficiency, especially for volatile organic compounds in air.

Accuracy and quality control in trace element analysis, J. H. Boutwell, *SP422,* pp. 35-40 (Aug. 1976).

Key words: accuracy and precision; clinical chemistry; quality control; surrogate specimens; trace elements.

Trace element analysis, not uniquely, but to a unique degree, is affected by the problems associated with contamination of the specimen during the process of collection, as well as by the contamination of reagents and the environment during the process of analysis, which will be discussed in other presentations.

The quality control of accuracy in trace element analysis must therefore cover all phases of the analytical process, including collection. Such an extension makes it necessary to use surrogate specimen material with defined trace element(s) content beyond the laboratory, that is, in the sphere of specimen collection in the field, on a regular, protocol-directed basis. The protocol for using such surrogate specimens for accuracy control should be directed to the exposure and display of any variations in systematic bias which may occur. Such bias, or error, may be either positive or negative and may arise from defects or alterations in collection materials or in procedural errors in the collection process.

The nature of the surrogate specimens required for accuracy control depends upon both the type of specimens to be collected and analyzed and the details of the analytical process itself.

The role of the National Bureau of Standards Standard Reference Materials in accurate trace analysis, J. P. Cali and W. P. Reed, *SP422,* pp. 41-63 (Aug. 1976).

Key words: accuracy; accurate measurement system; precision; reference methods; standard reference material; systematic errors.

A meaningful measurement process is capable of producing numerical values of the property(ies) under test or mea-

surement that are compatible throughout the measurement infrastructure. By this we mean that all the measurement laboratories within a given industry or technological or scientific area are capable of and, in practice do, produce measurement values for a given property on a given material that are identical and immediately comparable within some agreed on uncertainty. Such measurement compatibility results when accurate measurements are the basis upon which the work is founded. When a measurement system is accurate, then the numerical values produced are free of systematic errors and are also precise. We will show that, in practice, a certain degree of precision must be obtained before assertions of accuracy can be realistically tested experimentally.

One mode by which accuracy may be transferred to all laboratories within a measurement infrastructure is through the use of reference materials used in conjunction with reference methods. At NBS reference materials are called Standard Reference Materials (SRM's). They are well-characterized materials (in terms of accurately determined properties) useful for the calibration and/or assessment of a measurement system. When SRM's are used in conjunction with a reference method, i.e., one of demonstrated accuracy, then it becomes possible to transfer accuracy throughout an entire measurement infrastructure. How this is accomplished will be discussed.

Obviously the assurance of the "built-in" accuracy of the SRM is critical. How this is done at NBS will be discussed. Finally, currently available SRM's useful in trace analysis will be considered, as well as work now in process and future plans for additional trace SRM's.

Interpretation of accuracy of trace element results in biological materials, G. H. Morrison, *SP422,* pp. 65-77 (Aug. 1976).

Key words: accuracy; biological materials; data interpretation; standard materials; trace elements.

With the recent realization that trace elements have a very important role, either beneficial or harmful, in man, trace element analysis has become an increasingly important field of research in clinical medicine, biology, nutrition, and environmental studies. Many researchers have investigated the amounts of various elements in man, animals, plants, and types of tissues.

The interpretation of trace analytical results for biological materials is discussed from the viewpoint of their accuracy. Interpretation of results of an analysis of an unknown sample depends to a great extent on prior evaluation of the analytical method employed. The accuracy of the method is best determined by the analysis of standard samples. In the absence of standard samples of a similar nature to the unknown samples, the results of the method are compared with those obtained by other methods of analysis. Both of these approaches are discussed. An evaluation of published results for the determination of the 15 trace constituents in the standard reference material Orchard Leaves is presented from the viewpoint of accuracy.

A case history is presented to illustrate the problems associated in the development of a method for a biological sample and the evaluation of the accuracy of the method.

Precision and accuracy in silicate analysis, S. S. Goldich, *SP422,* pp. 79-89 (Aug. 1976).

Key words: accuracy; analytical bias; reference samples; silicate analysis.

The precision and accuracy of analytical results in geological publications range widely. High-quality analyses are typical of the research in geochronology and in other areas of isotopic investigations, and this work has resulted in substantial improvement in the data that are now evolving in more routine geological investigations. The trace elements Rb, Sr, Ba, and the rare earth elements are widely used in petrological investigations, and accurate results are obtained routinely by isotope-dilution techniques and mass spectrometric measurements. It is now commonplace for the results from different laboratories to agree within 1 to 2 percent of the amount present. In contrast, the results from atomic absorption, x-ray fluorescence, neutron activation, and optical spectrographic methods are much more variable and are less reliable. The increasing availability of reference samples is easing some of the problems of the instrumental analyst, but the reference samples have some problems of their own. The lack of well-characterized reference samples is a major barrier to better quality instrumental analyses.

Use and interpretation of water quality data, W. T. Sayers and W. R. Ott, *SP422,* pp. 91-107 (Aug. 1976).

Key words: accuracy; data interpretation; monitoring; water; water quality.

Water quality data are collected by State and Federal pollution control agencies to characterize baseline quality, identify trends, detect and document violations in quality standards and discharge permit conditions, develop mathematical models for determining present and future pollution control requirements, and characterize the movement, fate, and effects of specific pollutants entering the water environment. This information is used in formulating and implementing water quality management goals, strategies, and plans and in evaluating the effectiveness of resulting local, State, and Federal pollution abatement efforts. The kinds of interpretations to be made from water quality data, the interpretive methods to be used, and the level of reliability desired of the results must all be decided before an effective sampling program can be designed. These considerations dictate the number and spatial arrangement of stations, the parameters to be evaluated, sampling frequencies, and the duration of the sampling program. Because of supportive relationships among parameters, data on a given parameter are seldom evaluated independently of the data on the other parameters measured. Results are grouped in various combinations and displayed in any of a number of ways for interpretation, depending on the objectives in mind. Statistical procedures are an important tool in the interpretive process, but should never be used as a substitute for judgment. The economic and other impacts of management/legal decisions based on the data require that proper consideration be given to data reliability measures and the confidence levels of the results obtained, in addition to the results themselves.

Interpretation of clinical laboratory data, D. S. Young, *SP422,* pp. 109-122 (Aug. 1976).

Key words: accuracy, precision and specificity of analytical methods; biological and genetic variability; clinical laboratory data; specimen collection; specimen handling.

The central role of the clinical laboratory in the diagnosis of some diseases is discussed as well as some of the potential consequences of misinterpretation. Examples of the influence of both *in-vivo* and *in-vitro* factors on the interpretation of results are presented.

The genetic background and biological variability of the individual influences the data, even when he is healthy. The disease process may have a greater or lesser effect on laboratory data. In general, physicians usually request those

tests to be performed that they anticipate being abnormal, so that the influence of disease on the test performed in the clinical laboratory is usually quite large. Other *in-vivo* influences include the mode of collection of specimens for analysis. Outside the patient the preparation of the specimen for analysis may affect the analytical results. Finally, the accuracy, precision and specificity of the analytical procedures in the clinical laboratory affect the data. It is only this group of factors that the clinical chemist is able to control and yet knowledge of both laboratory and patient factors is essential for the correct interpretation of data.

The analyst and accuracy, F. P. Byrne, *SP422*, pp. 123-126 (Aug. 1976).

Key words: accuracy; analytical chemistry; standard reference material; statistics; syndrome.

It sometimes happens that an analytical chemist, in evaluating the accuracy of his analysis, subconsciously obtains highly precise and accurate analyses, when in fact, the method and techniques he uses cannot possibly yield such results. This can happen even when he uses standard reference materials or carries out a series of repetitive analyses. Examples of these are discussed along with examples of other human foibles that may leave the analyst with a false impression of his accuracy and precision.

Detection of systematic errors by the analysis of precision, K. Heydorn, *SP422*, pp. 127-139 (Aug. 1976).

Key words: accuracy; analysis of precision; *a priori* error; *a priori* precision; *a posteriori* precision; chi-square test; precision; precision of analytical method; ultratrace level.

The extension of accuracy in trace element analysis to the ppb level cannot be based directly on the study of Standard Reference Materials because most of these are certified only at the ppm levels. Control of accuracy at such low levels may be achieved by an analysis of precision which serves to detect unknown sources of variation in replicate measurements. This approach was used to locate errors in connection with the determination of arsenic in human serum by neutron activation analysis. Successive applications of the analysis of precision led to the detection of two unknown sources of variation. In addition, the analysis of precision indicated that the current evaluation of small photopeak areas was not entirely unbiased. The apprehension of these errors led to changes in the methodology which in turn yielded both better precision and improved accuracy at the ppb level of concentration.

Detection of systematic error in routine trace analysis, D. E. King, *SP422*, pp. 141-150 (Aug. 1976).

Key words: analytical performance; between-run; calibration; precision; quality control; systematic error; Youden plot.

The Youden technique has been modified in order to monitor systematic error between runs. When a laboratory appears to have systematic error problems, it is important to know whether or not this is typical of the routine operation. The procedure to be described examines the sum and difference of the results obtained on each of two control samples. Simple statistics permit long-term analysis of the results of such control analyses to separate within-run, or random effects, from the systematic effects occurring between runs. This simple sum/difference approach has been applied in a wide variety of water and wastewater analytical procedures. The blank determination in trace analysis has been implicated, in many cases, as the most significant source of systematic error.

The application of cluster analysis to trace elemental concentrations in geological and biological matrices, E. W. Stromberg and J. L. Fasching, *SP422*, pp. 151-162 (Aug. 1976).

Key words: air particulates; blood; chemistry; computer graphics; geochemistry; medicine; pattern recognition; trace elements.

In the past it has been difficult to accurately interpret the information provided by trace elemental analysis, especially when concerned with biological and geological studies where there may be many variables involved other than simple elemental distributions. Utilizing a combination of hierarchical cluster analysis, factor analysis, and canonical correlation, data is presented showing how these three statistical methods may be combined to study the relationships of trace elemental concentrations in geological and biological matrices. Clusters of elements are found which are not readily apparent from examination of either raw data or simple correlation matrices.

Individual variation of trace metal content in fish, J. R. Montgomery, S. E. Kolehmainen, M. D. Banus, B. J. Bendien, J. L. Donaldson, and J. A. Ramìrez, *SP422*, pp. 163-172 (Aug. 1976).

Key words: atomic absorption spectroscopy; fish analysis; sample size variations; trace analysis; trace metals.

Fifty herring *Opisthonema oglinum* (Le Sueur) were collected from Boquerón Bay, Puerto Rico in one gill net haul. Each whole fish was wet-digested and analyzed as a separate sample in triplicate for Fe, Zn, Pb, Cd, Cu, and Mn using atomic absorption spectrophotometry. Results were correlated to the size of the fish. The concentration of Fe, Zn, Cd, and Cu was significantly higher in the pooled small fish as compared to the pooled large fish. The Pb concentration showed no detectable difference between the size classes. However, the Mn concentration was significantly higher in the pooled large fish as compared to the pooled small fish. The mean concentrations of these metals were statistically compared to the results of a pooled sample of fish collected and analyzed identically and to a pooled sample of thread herring collected in another location at a different time. No significant difference was found between these two pooled samples of medium size fish or between the trace metal values for the individual medium size fish. A determination of the sample size necessary to detect a 15, 20, and 25 percent difference between two significantly different means showed that a minimum sample size to detect that magnitude of difference would be 124, 70, or 50 fish respectively.

Accuracy of chemical analysis of airborne particulates—results of an intercomparison exercise, F. Girardi, *SP422*, pp. 173-188 (Aug. 1976).

Key words: accuracy; activation analysis; airborne particulates; air filter analysis; atomic absorption; emission spectroscopy; environmental pollutants; intercomparisons; multi-element analysis; trace element analysis; x-ray fluorescence.

Since suitable standard reference materials for chemical analysis of airborne particulates are not available, an intercomparison exercise was carried out among 40 interested laboratories in order to evaluate the accuracy of various trace analysis techniques for this specific application. Six

hundred grams of airborne particulates were collected from the inlet filters of the air conditioning installation of a hotel in the center of Milan. The sample was sieved to remove coarser particles, thoroughly mixed, and distributed in 1 to 5 gram aliquots. The homogeneity was checked by relative measurements carried out by three independent techniques. For 40 elements no inhomogeneity was found to exceed the analytical error, which was estimated to be approximately 10 percent. The data of the analytical exercise are being collected and evaluated. Results are available for 56 elements, but to date only 33 have been determined by more than one technique. Activation analysis, emission spectroscopy, atomic absorption, x-ray fluorescence and various wet chemical methods contributed to the intercomparison. No result was received from mass spectroscopic methods and, although analyses were specifically encouraged, very few results were received on the organic components. From a first approximate evaluation a good agreement was found for Al, Fe, Zn, Mn, Ca, Pb, Cl, S, Si, Ti, Mn, while for the other elements no definite conclusion can yet be drawn. An attempt will be made to interpret important cases of systematic errors, a few of which are already evident.

The estimation of accuracy in trace analysis. Results obtained from intercomparisons organized by the I.A.E.A., L. Górski, J. Heinonen, and O. Suschny, *SP422*, pp. 189-197 (Aug. 1976).

Key words: accuracy; activation analysis; air filter analysis; analytical quality control; atomic absorption spectrometry; environmental analysis; fresh water analysis; intercomparisons; precision; round-robin experiments; trace element analysis.

The 1972 and 1973 I.A.E.A. round-robin exercises concerning trace analysis in environmental problems are reported. Paper filters simulating air filters were spiked with known amounts of salts of: As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, V, and Zn, in the order of micrograms of an element per one filter. Only Fe and Pb were present in the order of 200 μg. Twenty-two laboratories returned 922 analytical results obtained by 6 different methods – mostly neutron activation analysis and atomic absorption spectrometry. Tables summarizing the results for each element are presented with special emphasis on the difference between the true value and the reported results. The need and the utility of the Analytical Quality Control programme of the Agency is also discussed.

Accuracy assurance in the analysis of environmental samples, R. K. Skogerboe and S. R. Koirtyohann, *SP422*, pp. 199-210 (Aug. 1976).

Key words: accuracy; anodic stripping voltammetry; arc emission spectroscopy; atomic absorption; environmental analyses; interlaboratory tests; neutron activation analysis; plasma emission; round robin; x-ray fluorescence.

Three soils, two freeze dried blood pools, two (NBS) plant leaf samples, and one (NBS) freeze dried liver sample were analyzed in an interlaboratory program undertaken by NSF(RANN). Three independent methods produced agreement within $\pm$ 20 percent for the soils and pooled blood. The values for the plant leaves were within the experimental error as estimated by the standard deviations given for the round robin results. The liver results showed excessive scatter.

Subsequent tests included the use of NBS reference samples, the preparation of secondary reference materials, resubmission of previously analyzed samples, and the use of several methods for the same determination. Methods used for cross checking included atomic absorption with and without chemical separation, nonflame atomic absorption, arc emission spectroscopy, plasma emission, anodic stripping voltammetry, neutron activation analysis and x-ray fluorescence. In most cases the agreement between methods was good, but enough problems were identified and subsequently corrected to establish the value of the program.

The steps taken in the two laboratories represent an adequate, yet practically attainable program to assure accurate results in a centralized analytical support laboratory for a university or other large research organization.

Four-laboratory comparative instrumental nuclear analysis of the NBS Coal and Fly Ash Standard Reference Materials, J. M. Ondov, W. H. Zoller, I. Olmez, N. K. Aras, G. E. Gordon, L. A. Rancitelli, K. H. Abel, R. H. Filby, K. R. Shah, and R. C. Ragaini, *SP422*, pp. 211-223 (Aug. 1976).

Key words: analytical methods; coal; environmental samples; environmental standards; fly ash; instrumental neutron activation analysis (INAA); instrumental photon activation analysis (IPAA); natural radioactivity; standard reference materials; trace elements.

The NBS coal and fly ash Standard Reference Materials (SRM 1632 and 1633) were analyzed for 37 elements in coal and 41 elements in fly ash mainly by the use of instrumental neutron activation analysis (INAA), augmented by instrumental photon activation analysis (IPAA) and direct counting of natural γ-ray activity. For most elements measured, there was excellent interlaboratory agreement between the four participating laboratories and with the National Bureau of Standards values for elements measured by them and in this work. In cases of most elements for which comparisons can be made, instrumental nuclear methods used in a round-robin study of the standards provided more accurate average concentrations and smaller interlaboratory dispersions of values than the other major techniques used, atomic absorption spectrometry and optical emission spectroscopy.

Trace element studies of a selected portion of the Mahoning River system, I. Mahadeviah, E. Mooney, and R. Munteau, *SP422*, pp. 225-230 (Aug. 1976).

Key words: atomic absorption analysis; Californium-252; Mahoning River: neutron activation analysis; pollution; sediment; trace elements; water; wet chemical analysis.

The Mahoning River flows through a highly industrialized section of eastern Ohio. It is used as a dumping ground for both solid and liquid wastes by both industry and municipalities along its banks.

Both water and sediment samples were collected at predetermined sites on a section of the Mahoning River running from its headwaters into and beyond one of the industrialized areas. The water samples were analysed for trace elements by neutron activation analysis (NAA) employing Youngstown State University's 10 mg Californium-252 neutron source, wet chemical techniques, and atomic absorption (AA). Certain trace elements, Ca and Mg, in the water samples were detected by all three methods. Comparison of results showed good agreement between NAA and wet chemical analysis for most samples. AA data, for the most part differed considerably from both NAA and wet chemical analysis. Subsequent tests have shown that organics, which are plentiful in the Mahoning River, are responsible for erroneous results in AA analysis.

Neutron activation analysis was shown to be the simplest of the three methods for trace element analysis and the location of possible sources of pollution.

Analysis of 11 elements in biological material. Comparison of neutron activation analysis and atomic absorption analysis, H. Wesch and A. Bindl, *SP422*, pp. 231-238 (Aug. 1976).

Key words: atomic absorption spectroscopy (AAS); comparison between NAA and AAS; neutron activation analysis (NAA); time of analysis in NAA and AAS; trace element content in liver biopsies; trace element content in tumor bearing animals; Wilson's disease.

Seven trace elements (Co, Cu, Fe, Mn, Mo, Se, Zn) and four bulk elements (Ca, K, Mg, Na) were analyzed by means of neutron activation analysis and flame or flameless atomic absorption analysis.

The organic material was destroyed by wet or low temperature ashing. Four different possibilities of analysis result from this arrangement. Time of analysis, accuracy, reproducibility and real, not theoretical, detection limit will be reported for each arrangement. The analyses were carried out with the 1577 NBS liver standard and our own liver standard. The techniques will be discussed in reference to clinical and research applications. The reported results will be based on analysis of liver biopsies and animal experiments.

Determination of zinc in environmental matrices: A comparison of results obtained by independent methods, M. Gallorini and E. Orvini, *SP422*, pp. 239-245 (Aug. 1976).

Key words: accuracy; atomic absorption; environment; neutron activation analysis; precision; x-ray fluorescence.

Zinc determination results in environmental matrices as reported by different laboratories in some recent interlaboratory comparisons, seems to have large biases. In order to achieve a better solution of the problem, an evaluation of four different methods for the determination of zinc content in environmental matrices is underway in our laboratory.

The suggested methods are: a) XRF x-ray fluorescence, b) NAA(I) instrumental neutron activation analysis, c) NAA(RC) neutron activation analysis, via radiochemical separation, and d) AAS atomic absorption spectrometry. Each of these techniques give information on some critical step typical of each different method. SRF and NAA(I) require no sample treatment or \dissolution \or chemical procedures, and insure no loss of any component and no danger of contamination. Unfortunately some interference due to some matrix content may occur, affecting in both ways the accuracy of the results. NAA(RC) techniques give results free from interferences from contamination, but require wet dissolution of samples or high temperature treatment which may affect the analytical results. AAS analysis may be affected by contamination from reagents and by the difficulties related to the sample dissolution. A critical evaluation of results acquired through these different methodologies on a dust sample is discussed.

Reliability of trace metal determination in freshwater by flameless atomic absorption (graphite tube atomization) in comparison with other chemical and physical methods, R. Wagemann, *SP422*, pp. 247-265 (Aug. 1976).

Key words: accuracy; flameless atomic absorption; freshwater; interlaboratory comparison; method evaluation; trace metal analysis.

An interlaboratory study of trace metal analyses involving seven different laboratories has been carried out, using river water samples and "synthetic" standards. The analytical precision for the flameless atomic absorption with graphite tube atomization was also established for eight different metals at various trace concentrations. The flameless atomic absorption method with graphite tube atomization is compared with 16 other techniques and methods used in the interlaboratory study, and the conclusion is reached that for a number of commonly determined metals the flameless atomic absorption method of measuring trace concentrations in dilute fresh water is as accurate a method as other more established methods. The relative standard deviation for interlaboratory determination of traces of zinc is consistently large, which indicates that this metal is relatively more difficult to measure accurately than most other metals that were investigated. The available analytical data for arsenic is small but sufficiently discrepant to indicate that arsenic is a most difficult metal to measure accurately at trace levels by most of the methods tried.

The accuracy of determination for most of the metals investigated would appear to lie within 20 to 45 percent, at the concentration levels prevalent in unpolluted fresh water.

The preparation and certification of trace mercury in water standard reference materials, J. R. Moody, P. J. Paulsen, T. C. Rains, and H. L. Rook, *SP422*, pp. 267-273 (Aug. 1976).

Key words: atomic absorption spectrometry; isotope dilution analysis; mercury in water, trace analysis; mercury in water, stabilization of; neutron activation analysis; spark source mass spectrometry.

The study of mercury in natural water supplies requires a Standard Reference Material (SRM) with a certified concentration at the 1 ng/g level. NBS SRM's have been prepared with nominal mercury concentrations of 1.5 μg/g and 1.2 ng/g. Confirmation of these values was obtained by neutron activation, atomic absorption, and isotope dilution-spark source mass spectrometry (IDSSMS). Nitric acid and trace amounts of gold were added to achieve a stable mercury concentration. The precautions observed for cleaning the glass and Teflon containers, preparation of mercury solutions, and the packaging of the SRM's are given. As an example of the care needed in the analysis of mercury at these levels, specific details are presented for the chemistry required to prepare samples for the spark source mass spectrometer (SSMS).

The influence of limits of laboratory accuracy and precision on the interpretation of blood lead analyses for industrial lead hygiene control, A. C. Eckert, Jr., *SP422*, pp. 275-282 (Aug. 1976).

Key words: accuracy; blood lead analyses; clinical chemistry; industrial lead hygiene; interlaboratory correlations; lead hygiene control; occupational exposure standard criteria; occupational health control; precision; trace element analyses.

Good laboratory accuracy in blood lead analyses can be obtained under some conditions but evaluation of the consistency of analyses of blood samples feasibly obtained from workers in industrial lead plants continues to present significant problems. The need for accuracy in blood lead analyses for industrial lead hygiene control is misunderstood because more than 45 years ago, long before there was any knowledge of blood lead levels, control of clinical lead cases had been achieved, and by 1949, 20 years of successful maintenance of such control was reported. The desirability of having an objective criterion, such as a maximum allowable blood lead level, for protection of the health of industrial lead workers is evident. However, adequate consistency of trace element analyses, even in relatively simple inorganic

materials, is often not experienced even under some of the best conditions. Therefore, those who are concerned with reducing the lead hygiene control process to a routine, that can be administered in part by paramedical or nonmedical personnel, and those who are concerned with attempts to establish and enforce maximum allowable blood lead levels urgently need a clear statement that specifies the limits of the capability of the present technology to demonstrate the accuracy that would be essential to meet these objectives.

Sampling and sample preparation at the Geological Survey of Canada—The what, why, and how, J. A. Maxwell, *SP422,* pp. 285-297 (Aug. 1976).

Key words: contamination; geological sample; rocks and minerals; sample preparation; sampling; trace analysis; water sampling.

The landmass of Canada, with half of its 4 million square miles underlain by the Precambrian Canadian Shield, encompasses most of the main geological regions of North America, and presents the geoscientist with a wide diversity of geological terrains of varying degrees of complexity, economic interest and inaccessibility.

Among the chief concerns of the Geological Survey of Canada is that of providing a comprehensive inventory and understanding of the geological framework through its extensive field and laboratory studies, with emphasis upon those regions having high potential for the occurrence of additional economic mineral deposits.

Many factors influence the nature of a sampling program, which may vary from the taking of single "grab" specimens to the collection of large numbers of samples on the basis of a sampling pattern laid out according to a statistically devised plan, but the primary consideration is always to obtain a sample that will yield the best answer to the question being asked. Rocks, minerals, stream and lake sediments, soils, glacial deposits, water samples from lakes, streams, springs, muskeg and other sources, all of these have their use as a source of compositional, petrographic, isotopic, mineralogical, textural and other information.

Because of the often unique nature of a sample, the difficulty of obtaining additional samples, the succeeding extensive and frequently costly work to be done on the prepared material, and the conclusions that will be derived from the resulting data, it is of paramount importance that the sample be correctly prepared. Again, various factors must be considered in the choice of method to be used, but the overriding concern must be to ensure that the sample prepared for study is truly representative of the sample submitted.

Sampling of biological materials, A. Speecke, J. Hoste, and J. Versieck, *SP422,* pp. 299-310 (Aug. 1976).

Key words: biological materials; chromium; cobalt; contamination; manganese; sampling; serum.

As many so-called essential elements are present in biological fluids and tissues in the subnanogram/gram range, contamination-free sampling and storage prior to the actual analysis is primordial. This is particularly the case when an essentially blank-free method like activation analysis is applied.

The used surgical equipment and storage vessels must be checked for their content of elements to be determined and adequate cleaning procedures must be adopted. As the tendency of liquid (or wet) samples to pick up contaminants from the vessel walls is much greater than that of dry samples, a drying (lyophilization) step should be enforced as early as possible after collection. (This will also prevent to a great extent the loss of traces to the vessel.) All samples should also be protected from dust as in an urban, industrial or laboratory environment airborne particles are important pollutants. All sample treatment and storage must be done in a dust-free room.

A typical example (the collection of human blood) will be discussed *in extenso,* together with the design of a dust-free room of simple conception and reasonable cost.

The adequacy and success of these procedures with continuous discipline is illustrated by the very low concentrations in serum obtained for Cr, Mn, and Co, respectively 0.15, 0.5 and 0.1 ng/ml. Furthermore as these elements are essential and the samples practically uncontaminated, the results present a Gaussian frequency distribution with a small standard deviation.

Accuracy in air sampling, J. P. Lodge, Jr., *SP422,* pp. 311-320 (Aug. 1976).

Key words: accuracy and precision; air; air particulates; air pollution; analysis of air; atmosphere; gaseous pollutants; sampling air.

The physical act of sampling the atmosphere for the subsequent determination of its trace composition is complicated by the fact that the atmosphere is not an equilibrium system. It contains numerous species that are mutually incompatible with one another, but that survive to be measured because of their extreme dilution. These arise from many point sources, many of them sporadic in nature, and hence the atmosphere is poorly mixed, even on a relatively small scale. This leads to serious problems in attempting to isolate a small portion of atmosphere in a form that may be carried back to the laboratory for subsequent analysis—or even analyzed *in situ.*

The planning of atmospheric sampling is further complicated by the statistical properties of the system. Simultaneous or sequential measurements, for example, within a city are not independent numbers, but tend to be highly autocorrelated. As a result, statistical judgments as to the number of necessary measurements to define mean levels within acceptable limits of accuracy have generally been misleading. In point of fact, most measurement networks have been designed around an available budget rather than around statistical ideality, and frequently without a clear notion of the purpose of the resulting data.

The reduction of orders of magnitude errors in lead analyses of biological materials and natural waters by evaluating and controlling the extent and sources of industrial lead contamination introduced during sample collecting, handling, and analysis, C. C. Patterson and D. M. Settle, *SP422,* pp. 321-351 (Aug. 1976).

Key words: accuracy of atomic absorption analytical techniques; accuracy of isotope dilution analytical techniques; errors in lead analyses; lead; lead contamination evaluation and control; lead in animals and plants; pollution, lead; sampling techniques; trace analysis of lead; waters, lead in.

Most present analytical practices for lead cannot reliably determine lead concentrations at the 1 ng/g level because of a universal lack of familiarity with lead contamination during sample collecting, handling and analysis. Consequently, the great mass of published data on lead in plant and animal tissue and in water is associated with gross positive errors which obscure the meaning of most work dealing with lead at the few μg/g level.

It can be stated unequivocally that for lead concentrations in the μg/g range or less the investigator must know with certainty the magnitude of the contribution of lead from each individual reagent, from air exposure, and from container walls; furthermore he must know the yields for each step in the chemical separation procedure so that he can modify the contamination contribution at any given step caused by yields of less than 100 percent in the preceding step.

Techniques for the collection of uncontaminated samples of fresh water, snow, sea water, and animal tissue are described. A clean laboratory for low level lead analyses is also described and other sources of lead contamination are discussed and means of control evaluated.

Sampling for clinical chemistry, F. A. Ibbott, *SP422,* pp. 353-361 (Aug. 1976).

Key words: accuracy and precision; analysis of body fluids; clinical analysis; clinical chemistry; clinical sampling; enzyme analysis; storage of clinical samples.

Three requisites must be satisfied for a physiological sample to be acceptable for analysis in the clinical chemistry laboratory. If any of these three requisites is not met, the acquisition of a reliable and meaningful result is jeopardized.

To begin with, at the time the sample is collected, the patient must be in a physical state appropriate for the contemplated assay. Some of these physical requirements are reasonably apparent such as observance of being fasting, or supine, and avoidance of hyperventilation. An example that is less obvious concerns the interference by radioactive material already present in the patient's blood upon a radioimmunoassay.

The second requirement is for the blood drawn from the patient to be truly representative of that in the circulation. This implies circumvention of trauma to body tissues, avoidance of damage to the blood cells and alertness to the possible introduction of contaminants.

Finally, the specimen must be maintained in a manner that preserves its composition with regard to the parameter to be measured. While certain analytes remain stable for long periods, others require the use of chemical preservatives or that the sample be frozen. In some instances, no practical method of preservation has been developed.

High-purity reagents for trace analysis, M. Zief and J. Horvath, *SP422,* pp. 363-375 (Aug. 1976).

Key words: analytical blanks; analytical reagents; contamination control; high-purity reagents; membrane filtration; mercury cathode electrolysis; prepurification; purity definition; reagent contamination; ultrapurification.

Determination of ultratrace (<1 μg/g) metal content in diverse matrices requires high-purity reagents for dissolution, preconcentration and supporting electrolytes. Trace impurities in these reagents fluctuate not only with the degree of contamination during purification and containment by the manufacturer but also with the care exercised by the analyst.

Particulates are a prime source of ultratrace impurities in inorganic salts. Most of the Fe, Pb and Cu in water soluble sodium and potassium reagents can be removed by submicrometer filtration under pressure. These impurities can be further reduced by mercury cathode electrolysis.

Although liquids are more easily purified, they are not stored as easily as solids. Accelerated aging studies for liquids, particularly the mineral acids, in leached glass or plastic containers are necessary to insure the integrity of the product. After the chemical has been purified and stored, it must be equilibrated with its container and analyzed under contamination-free conditions. Until full, accurate disclosure of procedural details for ultratrace measurements are published by suppliers and the laboratory analyst, inaccuracies attributed to systematic errors can be expected. Improper handling of high-purity reagents is frequently observed. For example, there is no point to use an expensive reagent when the container is allowed to collect dust on an open shelf or in the fume hood of a heavily contaminated laboratory.

Contamination of atmospheric particulate matter collected at remote shipboard and island locations, E. J. Hoffman, G. L. Hoffman, and R. A. Duce, *SP422,* pp. 377-388 (Aug. 1976).

Key words: analytical blanks; atmospheric sampling; coastal sampling; contamination of atmospheric particulate samples; sample handling; shipboard atmospheric sampling.

As part of a study of the chemistry of marine aerosols, atmospheric particulate samples have been collected simultaneously on the bow and on the stern of the University of Rhode Island oceanographic vessel TRIDENT to determine the degree to which particulates generated or modified by the ship itself can influence the chemistry of ambient air particulates. Samples have been analyzed for a variety of trace elements, including Na, Mg, Ca, K, Fe, Cu, Mn, Al, and Pb. The results indicate that certain elements are most subject to this form of contamination.

It is possible to use meteorological parameters to determine whether or not samples are contaminated by local sources. Atmospheric particulate samples have been collected from coastal towers in Hawaii and Bermuda. The composition of the particulates at the Hawaii tower is dependent not only on meteorological conditions at the time of collection, but also on conditions *(e.g.,* wind direction, rainfall, *etc.)* 24 hours previous to sample collection. Detailed meteorological information is thus critical in remote locations to determine whether or not the sample collected is representative of the ambient atmosphere.

Sampling and analysis for sulfur compounds in automobile exhaust, E. R. Blosser, L. J. Hillenbrand, J. Lathouse, W. R. Pierson, and J. W. Butler, *SP422,* pp. 389-400 (Aug. 1976).

Key words: automobile exhaust; catalytic oxidation converter; dilution tunnel; isopropanol; particulate filtration; sulfate; sulfur dioxide; sulfur trioxide; sulfur trioxide condensation.

Fuel sulfur is oxidized to the dioxide and trioxide in automobile engines. Adding an oxidation catalyst for emission control may alter the SO_3/SO_2 ratio in the exhaust.

An engine, a current production V-8 equipped with 1975 emission controls including an oxidizing catalytic converter (but without exhaust-gas recirculation), was run at steady operating conditions on an engine dynamometer. The exhaust was passed through a conventional exhaust system to a 23-in-diameter, 36-ft-long dilution tunnel.

Samples were withdrawn from before and after the catalytic converter, from the tailpipe, and from before and after filters sampling the diluted exhaust in the tunnel. Material balances for the fuel sulfur were carefully checked to ensure that valid data were being obtained.

Experiments were conducted with several catalysts, at two levels of fuel sulfur content. The results indicate less than 1 percent conversion to sulfate when the catalyst is not used, but substantial conversion to sulfate with the catalyst in use at the operating conditions of the experiments. A large increase in particulate mass is observed with the

catalyst; the increase has been shown to be largely sulfuric acid and associated water.

Considerable care must be exercised in the sampling and analysis of exhaust sample if errors are to be avoided. Details of the overall method, and reasons for the precautions taken will be presented, with data supporting the conclusions.

Preparation, analysis, and sampling constants for a biotite, C. O. Ingamells and J. C. Engels, *SP422,* pp. 401-419 (Aug. 1976).

Key words: biotite stoichiometry; geochemical standards; geochronological standards; K-Ar dating; sampling a biotite; sampling constants; standard biotite.

A 99.9+ percent pure 40-60 mesh biotite, intended primarily as a K-Ar dating standard, but useful in other applications, has been exhaustively analyzed. About 8 kilograms have been prepared for distribution.

Sampling constants K_s (*i.e.,* the weights of samples necessary for 1% sampling error) have been determined for potassium (0.005 g), for sodium (1 g), for total iron (0.005 g), for calcium (2 g), for aluminum (0.001 g), and for some other elements. Nonuniformity with respect to potassium, sodium, and calcium may be partly due to diadochic substitution: nonuniformity with respect to calcium may be caused in part by 0.02 percent of apatite impurity. There is evidence that the biotite is geochronologically inhomogeneous; it behaves as a mixture of two biotites of different K-Ar ages. The sampling constant for radiogenic argon is about 0.05.

Possibly the greatest value of this standard material will lie in its demonstration of the principles which ought to be observed during the preparation and distribution of geochemical standards. We hope that may be the first in a series of International Standard rocks and minerals which may be used with confidence to calibrate and control geochemical analysis.

An approximate method of computing errors in trace analysis due to sampling heterogeneous solids, F. J. Flanagan, *SP422,* pp. 421-427 (Aug. 1976).

Key words: analytical error; geochemical variance; particle size distribution; particle size errors; sampling errors; trace analysis.

An approximate method of computing errors in the determination of trace elements in silicate rocks, errors that may be attributable to the size distribution at the sample grains, has been derived using the Poisson distribution and assuming no covariance between minerals and grain sizes. Standard deviations of trace-element analyses decrease as particle size decreases and as number of particles increases. Before a crushed rock is sampled, the analyst should ensure that the number of particles is so large that the relative error due to the number of grains in the portion for analysis will always be a magnitude or two less than other errors he may make in the analytical procedure.

Sampling and analysis of carbon contained in the primary coolant of pressurized water reactors, S. A. Meacham, *SP422,* pp. 429-438 (Aug. 1976).

Key words: analysis; carbon; crud; filtration; pressurized water reactors; primary coolant; sampling; water.

A portable high pressure in-line filtration device, developed by the Westinghouse Analytical Laboratories, was installed in a pressurized water reactor (PWR) primary coolant sample line and the suspended solids removed by filtration.

The filtration medium was a 47 mm diameter silver filter having a porosity of 0.45 μm. Collection times of 8 hours with an average flow rate of 2.66 liters per minute (42.1 gal h^{-1}) were made. Total volume of primary coolant processed per run was 1,275 liters and resulted in the collection of 3.3 milligrams of suspended solids; more commonly known as crud. This corresponded to a concentration of 2.6 $\mu g\,\ell^{-1}$ or 2.6 ppb in the coolant.

After sufficient crud has been collected, the pre-tared silver filter is removed from the high pressure housing, dried, and reweighed. Eleven millimeter diameter discs are cut from the filter and placed in a preconditioned quartz combustion system and heated to 1150 °C within 30 minutes. An additional hour at 1150 °C is required to ensure complete reaction of the crud sample with the oxidizing atmosphere. The quantitative liberation of carbon dioxide is collected in a trap cooled with liquid nitrogen and subsequently released and measured by gas chromatography. Provisions are made for blank determinations on an unused silver filter with appropriate corrections and aliquot size determined by gamma spectroscopy.

The method developed for this analysis is applicable in the range of 1 to 200 micrograms of carbon. The accuracy and precision of the sampling method and the analytical procedure are discussed.

Sampling and sample handling for activation analysis of river water, S. H. Harrison, P. D. LaFleur, and W. Zoller, *SP422,* pp. 439-455 (Aug. 1976).

Key words: filtering water; river water; sampling water for trace elements; suspended particulates in water; Teflon water sampler; trace elements; trace elements in water; water.

A complete preanalysis scheme for determining trace elements in river and estuarine water by instrumental neutron activation analysis is described. The design, operation and evaluation of a new Teflon water sampler is included in the presentation of the preanalysis scheme. The evaluation of this water sampler consists of replicate sampling experiments and a comparison with a commercial sampling bottle (Van Dorn). The water sampler described allows for filtration of the sample as it is transferred from the sampler to a storage container. Lyophilization (freeze drying) is used as the preconcentration technique for the dissolved species, *i.e.,* liquid portion of the sample. Normalization of suspended particulate data to the element scandium is presented as a useful technique for locating man-made heavy metal input sources.

Homogeneity considerations in trace analyses using the nuclear track technique, B. S. Carpenter and G. M. Reimer, *SP422,* pp. 457-459 (Aug. 1976).

Key words: detector techniques; nuclear track analysis; sample homogeneity.

Nuclear track results are compared to those obtained by other analytical methods using different quantities of homogeneous material.

Two different approaches are used to make the nuclear trace analysis of a sample more representative of the larger sample. Sample homogenization methods and detector manipulation are discussed.

Problems in sample treatment in trace analysis, C. W. Sill, *SP422,* pp. 463-490 (Aug. 1976).

Key words: ashing (wet and dry); chemical errors; contamination; dissolution techniques; fusion dissolution; radiochemical analyses.

One of the most important—and most neglected—parts of any analytical procedure is the initial decomposition of the sample. Not only must the sample matrix be dissolved but the element sought must be converted reliably to the proper ionic form before chemical reactions characteristic of that element can be obtained. Complete dissolution is especially difficult with the quadrivalent and pentavalent elements which form very refractory oxides, carbides, *etc.*, particularly after having been heated. For example, the plutonium in the ash remaining from dry ashing large samples of soft tissue requires much more powerful treatment for its complete conversion to the ionic state than merely boiling with nitric acid. Fusion with molten potassium fluoride is one of the simplest and most effective methods for dissolving metallic as well as siliceous refractories because of the stability of the fluoride complexes and the high reaction rates available at its melting point of 846 °C. Inclusion of a small quantity of potassium nitrate even permits rapid and complete dissolution of refractory carbides such as Carborundum. The cake can then be transposed either with sulfuric acid to a pyrosulfate fusion with simultaneous volatilization of both hydrogen fluoride and silicon tetrafluoride, or with nitric and boric acids to give a solution free of sulfate. Color slides of the entire process will be shown to demonstrate that the procedure is neither difficult nor time-consuming as is generally supposed.

Extremely serious problems can be introduced by evaporating solutions of quadrivalent elements to dryness or by neutralizing them to too high a pH. Powerful sequestering agents can be produced from orthophosphates in the sample that will completely change the course of the analysis unless recognized and provided for. Standardizations are frequently carried out in a careless and inaccurate manner. Contamination is one of the greatest problems in trace analysis and needs to be avoided by good management and understanding of the causes. Preservation of both samples and standards can be vastly improved by application of a little more fundamental chemistry. Many other important "details" will be discussed which are frequently ignored or overlooked because of preoccupation with the more glamorous facets of the procedure, such as elegant separations or measurement techniques employed.

Dissolution of organic materials, T. T. Gorsuch, *SP422*, pp. 491-507 (Aug. 1976).

Key words: ashing techniques; dissolution; dry ashing; organic materials analysis; trace element analysis; wet ashing.

The initial stage in the determination of trace elements, the destruction of the organic matter, is likely to introduce more errors than all the other stages put together.

There are two main families of decomposition methods, those involving air or oxygen and carried out at relatively high temperatures and those involving relatively large quantities of liquid reagents and carried out at temperatures limited by the boiling points of the liquids. Each of them has its advantages and disadvantages. The dry methods generally being characterized by high and relatively less controlled temperatures and with little or no separation of the required elements and the other solid components of the system, while with regard to the wet methods, the temperature is generally lower and there is separation at all times between the required elements and the solid components of the system. The technique using activated oxygen falls into a separate class of its own.

The problems during the decomposition stage are of two kinds, losses of the required elements, or contamination of the sample with extraneous material. The losses can be due to volatilization or to fixation on the solid components of the system and such losses are generally less serious with wet methods than with dry. Contamination on the other hand is often related to the quantities of reagents added and in this instance the dry methods are probably superior to the wet.

The problems encountered, particularly with regard to losses, will vary greatly with the element to be determined and the nature of the sample in which it is to be determined. Elements such as mercury and selenium are always difficult and samples containing chlorine in any form generally pose problems.

The role of the analytical blank in accurate trace analysis, T. J. Murphy, *SP422*, pp. 509-539 (Aug. 1976).

Key words: accuracy; analysts; apparatus; blank; contamination; environment; purity; reagents.

The inability to control the analytical blank, *i.e.*, contamination from all sources external to the sample, has seriously affected the accuracy of low level trace determinations. Most of the sources of the blank are variable and it is this variability that determines the uncertainty of the blank correction and, therefore, the lower limit of trace element concentration that can be determined with reliability. To improve both the accuracy and lower limit of trace determinations, it is imperative to control the variability of the analytical blank. The only practical way to accomplish this is to reduce the size of the blank itself by controlling the sources of the blank.

The analytical blank is composed of contamination from four principal sources, namely: the environment the analysis is performed in, the reagents used in the analysis, the apparatus used, and the analyst performing the analysis.

Environmental contamination is caused by particulates and gaseous compounds in the ambient air. Methods for reducing the blank from this source by the use of isolation chambers or "absolute" filters are described.

While commercially available high-purity reagents have helped the analyst to control the blank from reagents, they are frequently not low enough in trace element concentration and must be purified before use. Methods for the preparation of high-purity reagents, especially water and the mineral acids, are reviewed.

Contamination from beakers, containers, mortars and other apparatus can seriously affect the blank. Techniques for controlling this type of contamination are described with emphasis on the purity of materials.

The last source of contamination is that caused by the analyst during the analysis due to carelessness or poor technique. Suggestions are given to aid the analyst in this regard.

The analysis of surfaces and microstructural detail, F. Bacon and E. Lifshin, *SP422*, pp. 541-573 (Aug. 1976).

Key words: Auger spectrometry; electron microprobe analysis; ESCA; ion scattering; secondary ion mass spectrometry; surface analysis.

The spatial distribution of trace elements detected by bulk chemical analysis can be as important a factor in determining the properties of any material as its overall composition. In structural materials such as steel, for example, the presence of certain impurities below the 100 parts per million level, segregated to grain boundaries, can cause intergranular failure while a uniform distribution of the same con-

centration might have a negligible effect on mechanical properties. Similar examples can readily be cited regarding the influence of minor or trace constituents on electrical properties, corrosion, oxidation, adhesion and catalysis behavior.

New instruments for chemical analysis of fine structure and surfaces include electron and ion microanalyzers, as well as Auger, photoelectron and ion scattering spectrometers. It will be the purpose of this paper to review the present status and limitations of these techniques for local chemical analysis and discuss how they complement each other and more traditional methods of bulk chemical analysis.

The effects of container composition, storage duration, and temperature on serum mineral levels, G. L. Fisher, L. G. Davies, and L. S. Rosenblatt, *SP422*, pp. 575-591 (Aug. 1976).

Key words: atomic absorption spectrophotometry; calcium; container effects; copper; magnesium; potassium; serum minerals; serum storage effects; sodium; temperature effects; trace elements; zinc.

To evaluate the effects of various storage parameters on serum mineral levels, blood-bank pooled, human serum was stored in Erlenmeyer flasks of five different compositions at three temperatures. The samples were analyzed by atomic absorption techniques for calcium, magnesium, copper, zinc, sodium, and potassium at 0, 1, 2, 4, 8, 16, 32, and 50 days of storage. Container effects were highly significant for Zn, K, and Na, but were small with maximal container differences of 2 to 3 percent. To 16 days of storage, temperature effects were not significant, and at later times temperature was highly significant at room temperature for Ca, Mg, and Zn. The effect of storage time was highly significant for all elements: Zn showed a 20 percent decrease after 2 days; Ca, Mg, and Cu had 10 percent decreases at 2, 4, and 8 days, respectively; K and Na showed maximal decreases of 2 percent and 3.5 percent with storage time. For the elements Zn, Ca, Mg, and Na, decreases were observed after 4 days of storage with near return to the original values on day 8. The patterns of mineral change in serum suggested at least two mechanisms: (1) pH change and (2) at later times, bacterial growth. To test these hypotheses, two subsequent studies were initiated. In one study, pH of f shly pooled human serum was measured, and streak plates were counted for bacteria at the time of each elemental analysis under various storage conditions. In another study, serum pH changes were accelerated by physical techniques that accelerated the loss of CO_2. The data indicate that factors that influence serum pH levels appear to affect elemental concentrations.

Biological sample contamination due to quartz container in neutron activation analysis, B. Maziere, A. Gaudry, J. Gros, and D. Comar, *SP422*, pp. 593-604 (Aug. 1976).

Key words: biological analysis; container blank; neutron activation analysis; wet-ashing blank.

Activation analysis is not dependent on the purity of chemical reagents because these are used only after irradiation. However, in the analysis of biological samples a new source of "contamination" appears, due to the container in which the sample is irradiated. For this reason it is often necessary to separate the irradiated sample from its irradiation container before recording the activity. Since the quartz of the container is partly dissolved, it is necessary to eliminate contamination due to impurities adsorbed on the surface of the quartz ampoule. The values of the so-called "analytical blank" are given for some 15 elements, certain of which have a recognized importance in biology.

Preparation of biological materials for chromium analysis, W. R. Wolf and F. E. Greene, *SP422*, pp. 605-610 (Aug. 1976).

Key words: biological materials; biological standards; chromium; flameless atomic absorption; volatile chromium compounds.

In flameless atomic absorption spectrometry, introducing biological materials directly into a graphite furnace leads to a lower response than if the samples are pre-ashed. The decrease is due to organically bound chromium. Since few biological standards are available with reliable data as to chromium content, it is necessary to use inorganic standards of known chromium content and prepare the biological materials in such a way as to destroy the chemical history of the chromium. Studies were carried out on the NBS Standard Reference Material SRM-1577 (Bovine liver), looking at a variety of sample digestion and ashing procedures. An order of magnitude variation in chromium content was seen depending upon the type of sample preparation procedure used. The existence of volatile compounds of chromium that are lost during ashing or digestion steps has been postulated for an explanation of these different results.

Stability of chromium ions at low concentrations in aqueous and biological matrices stored in glass, polyethylene, and polycarbonate containers, V. D. Anand and D. M. Ducharme, *SP422*, pp. 611-619 (Aug. 1976).

Key words: adsorption losses; biological systems; chromium; stability; storage containers.

Low-concentration solutions of chromium (< 50 μg/dl), in either aqueous or biological matrices, frequently need to be stored for short or long term studies. Storage at low temperatures is usually considered the best available precaution against changes in concentration through adsorption or leaching or evaporation of water. Polyethylene containers are not appropriate for storage of aqueous chromium standards of low concentration. Borosilicate glass containers are preferred for the storage of low-concentration aqueous standards for up to 6 months. The stability of serum and plasma chromium concentration ($< 0.2 - 0.5$ μg/dl) is maintained in polyethylene vessels, if stored frozen at below -10 °C. Polycarbonate tubes were found adequate for storage of serum and plasma for up to 2 weeks, under refrigeration at 4 °C.

A possibility of state analysis of plasma spectrometry, S. Hanamura, *SP422*, pp. 621-625 (Aug. 1976).

Key words: plasma spectrometry; preliminary analysis; specimen decomposition; specimen evaporation.

This report describes a new method of state analysis by plasma spectrometry which is found to be very useful for preliminary analysis of natural samples. An induction furnace or an electric heater is used for the vaporization of this solid sample and the resulting gas is introduced into the plasma torch. The vaporized sample enters the plasma flame in the order of height of boiling point and depends upon the temperature gradient of the furnace.

Preparation and analysis of aquatic-related samples, N. M. Ferguson, J. R. Lund, R. R. Rickard, and L. T. Corbin, *SP422*, pp. 627-632 (Aug. 1976).

Key words: aquatic insects; atomic absorption; clean room; fish; mini-computer; sample preparation; toxic metals; trace determination.

The use of a special room in which to prepare samples and high-purity reagents has become standard now. However, without adopting and judiciously following special operating procedures to cope with those factors which affect the accuracy of trace analyses, the analyst may encounter serious problems.

Special operating procedures have been followed within the sample preparation laboratory to provide representative aliquots of aquatic-related samples (fish, aquatic insects, water, and water sediments) to other analysts for multiple element determinations. Procedures or preparation techniques employed for aquatic-related samples have been directed toward the final use of NAA, SSMS and AA for the desired determinations. Criteria have been established to aid in the selection of applicable analytical methods. Consideration is given to determining what degree of accuracy is adequate and to the expense necessary to achieve this accuracy. By following sound sample preparation procedures in the sample preparation laboratory and by taking great care in making the final determination or measurement, significant reductions in analytical costs can be realized without compromising the accuracy of the analysis.

Stability of metal ions in aqueous environmental samples, A. Rattonetti, *SP422,* pp. 633-648 (Aug. 1976).

Key words: filtration losses; metallic ions; pollution monitoring; rainwater analysis; sample stability; surface water analysis.

The time lapse between the collection of aqueous environmental samples and the analysis affects the original ionic concentration. Studies have proven the nonionic species in a water sample have more of an effect on the veracity of an analysis than the "container wall" effect, and that adjustment to a pH of 2 at sample collection time is a "Pyrrhic victory." Lead, for example, will commonly increase an order of magnitude when unfiltered samples are adjusted to a pH of 2 upon collection. This effect is greatest when elemental ions are present in the ng ml^{-1} range and lessens as the original ionic concentration increases.

Data is presented that behooves filtration of stream water and rainwater samples prior to any acidification step. The need to acidify the resulting filtrate is also discussed. Lithium, sodium, potassium, cesium, magnesium, calcium, strontium, manganese, iron, copper, silver, zinc, cadmium, aluminum, indium, and lead are examined. The insoluble phase retained on the filter can be digested with acid and also analyzed. The separate analysis of the filtrate and filter will give a true representation of the occurrence of these metals in nature. Flame and flameless atomic absorption and emission are used to perform the trace analyses.

Resin-loaded papers—sampling and trace analysis using neutron activation and x-ray spectrography, S. L. Law and W. J. Campbell, *SP422,* pp. 649-658 (Aug. 1976).

Key words: ion exchange; sampling; x-ray fluorescence.

Resin-loaded papers, composed of approximately 50 weight percent cellulose and 50 weight percent resin, provide an ideal medium for sampling large volumes of solution, then determining the concentrated elements by either fluorescent x-ray spectrography or neutron activation. This combination of chemistry and spectrography offers a versatile quantitative approach to the determination of trace elements in the ppm-ppb range. Standards and unknowns are prepared by either multiple filtration of solutions through two or more papers to measure the collection efficiency or a radiotracer is added to the solution to serve as a collection monitor. Reagent and paper blanks are incorporated into the analytical procedure. Papers containing strong acid or base resins collect a wide range of ions. Specific ions are collected by either chemical processing of the solution prior to filtration through the resin-loaded paper or by the use of papers loaded with chelating resins having high specificity.

Advantages of the resin-loaded paper approach prior to spectrography are: Improved analytical accuracy as the standards and unknowns are present in similar matrices; sampling errors are reduced and sensitivity significantly increased by concentration of the elements from a large volume of solution; and x-ray and gamma-ray spectral interferences are greatly reduced compared to bulk analysis. Also standard papers can be reused and stored indefinitely for x-ray applications.

Examples of published applications to a wide range of industrial, environmental, and health problems are summarized together with applications by the Bureau of Mines to metallurgical and mining problems. Potential applications of new ion exchange resins and reagent-loaded papers are also considered.

Losses, interferences, and contamination in trace metal analysis—some examples, F. Amore, *SP422,* pp. 661-668 (Aug. 1976).

Key words: analysis; ashing; blood lead; contamination; dairy products; digestion; interferences; losses; mercury; trace metal.

The three main problems confronting the analysts in trace metal determinations are losses, interferences, and contamination. These problems occur at all stages of the analysis. Procedures requiring a minimum amount of sample manipulation are, therefore, desirable. Examples such as losses of copper, cadmium, lead and chromium in dairy samples routinely surveyed fr these elements in both a dry ashing and wet digestion procedure are discussed. Examples and discussion of interference problems and sources of contamination are also given. The use of blanks and spiking and continuous monitoring practices are emphasized.

Sampling problems and the determination of mercury in surface water, seawater, and air, H. A. Das and H. A. van der Sloot, *SP422,* pp. 669-699 (Aug. 1976).

Key words: activation analysis; adsorption isotherm; environmental samples; mercury; preconcentration; trace elements.

Analysis of surface water for mercury comprises the determination of both ionic and organically bound mercury in solution and that of the total mercury content of the suspended matter. Eventually, metallic mercury has to be determined too. These determinations require a sampling procedure which meets the following requirements: a) the concentration of suspended matter is not affected, b) the separation of the solid fraction from the sample is performed immediately after sampling without losses from the aqueous phase due to absorption and losses from the solid phase due to desorption at a too low pH, and c) the aqueous phase is processed immediately to prevent losses due to absorption on the wall of the container. A method for the routine determination of mercury in surface water and seawater was developed and applied to Dutch surface waters. The total sample volume is 2500 ml. About 500 ml is used for the determination of the content of suspended matter and the total amount of mercury in the water. The sample is filtered through a bed of previously purified active charcoal at a low

flow-rate. The main portion (≃ 2000 ml) passes a flow-through centrifuge to separate the solid fraction. One liter is used to separate "inorganic" mercury by reduction, volatilization in an airstream and adsorption on active charcoal. The other liter is led through a column of active charcoal to collect all mercury. The procedures were checked with ^{197}Hg radiotracer both as an ion an uncorporated in organic compounds. The mercury is determined by thermal neutron activation, followed by volatilization in a tube furnace and adsorption on a fresh carbon bed. The limit of determination is ≃ 1 ng l^{-1}. The rate of desorption from and adsorption on suspended material has been measured as a function of the pH of the solution for Hg^{+2} and various other ions. It can be concluded that only the procedure mentioned above does not disturb the equilibrium. The separation of mercury from air is obtained by suction of 1 m^3 through a 0.22 μm filter and a charcoal bed. The determination is then performed as in the case of the water samples.

Control of blanks in the analysis of phthalates in air and ocean biota samples, C. S. Giam and H. S. Chan, *SP422*, pp. 701-708 (Aug. 1976).

Key words: air analysis; analytical blank; gas chromatography; ocean biota analysis; phthalate trace analysis.

For the trace characterization of phthalates, gas chromatographs equipped with electron-capture detectors have been found to be more sensitive than those with flame-ionization detectors in the order of about 10^2. But the response (measured by peak height) of phthalates to electron-capture detectors are in the order of 10^2 less sensitive than that of chlorinated hydrocarbons (DDT, DDE, PCBs, *etc.*). The response of phthalates to electron-capture detectors is not constant and normally as little as 0.5 nanogram of di-2-ethylhexyl phthalate (DEHP) can be detected.

The following factors limit the detection of phthalates at ultra-low levels (parts per billion to parts per trillion in biota samples) with acceptable accuracy: 1) contamination from solvents, reagents and materials used in the analysis; 2) limitation from the size of the samples; and 3) polychlorinated biphenyls (PCBs) and DEHP contamination in the laboratory and their strong adsorption to glass surfaces.

This paper will describe the problem of background contamination from various sources—reagents, solvents and materials used in the laboratory—the procedure for the removal of these contaminants and the methods for the isolation and separation of phthalates in air and open-ocean biota samples.

Mass spectrometric analysis for fractional ppb atomic content of boron in trichlorosilane, J. A. Baker, *SP422*, pp. 709-714 (Aug. 1976).

Key words: boron measurements; mass spectrometry; semiconductor grade silicon; trichlorosilane.

$HSiCl_3$ is used to make semiconductor grade silicon. This silicon must have a boron content in the low ppb atomic range as measured by resistivity analysis; thus, purity of the raw material $HSiCl_3$ must be known in advance. A mass spectrometric technique was developed to analyze quantitatively the boron content in the $HSiCl_3$ relative to the observed boron deposited in the silicon.

A fixed volume of $HSiCl_3$ was evaporated and hydrolyzed onto a cleaned silicon electrode; the electrode surface area was approximately 20 square mm. A point silicon counter electrode was scanned over the surface of the coated large area electrode to spark the "deposited" residue. To obtain a limit of detection of 3 ppb atomic in the bulk analysis of a solid it is necessary to spark and produce a 300 nanocoulomb exposure on the analyzing photoplate. The evaporation and hydrolysis of $HSiCl_3$ produces a concentration factor as later determined of approximately 1000; thus, a surface exposure of 3 nanocoulomb will give a limit of detection of 0.3 ppb atomic. Experiments were performed on 8 samples covering a wide range of boron content and 16 samples at or near the limit of detection. Mass spectrometric analysis of each $HSiCl_3$ sample was performed and silicon poly rods were grown from each $HSiCl_3$ sample. The poly rods were float zoned 1 and 10 pass to determine by resistivity the boron and donor concentrations in the poly. A calibration curve was then constructed comparing the mass spectrometric boron concentration and the boron as determined by resistivity. The concentration factor of approximately 1000 was thus obtained for the mass spectrometric analysis of boron in $HSiCl_3$. The observed boron content thus refers to the boron deposited in polycrystalline silicon by the $HSiCl_3$ and not the boron content in $HSiCl_3$. This distinction is necessary; to demonstrate that one analytical technique is producing correct results it is necessary to calibrate it against a known standard technique. The measurement of boron in silicon by resistivity is an accurate technique is producing correct results it is necessary to validated. Thus, an analytical technique has been developed to measure impurity concentrations (in this case boron in $HSiCl_3$) in the fractional ppb atomic range in liquids with great accuracy.

The challenge of getting the lead out, E. Berman, *SP422*, pp. 715-719 (Aug. 1976).

Key words: atomic absorption spectrometry; blood analyses; contaminations; flameless methods; lead; lead blood analyses; methodology; trace element analyses.

Developments in spectroscopic instrumentation over the last decade have enabled determinations of the lead content in blood, other biological fluids, and tissues to become routine analyses in clinical laboratories serving metropolitan centers. Though not a technically difficult procedure in itself, maintaining the quality of lead analyses presents a few challenges. One must be cognizant of the pitfalls of a specific method and of the limits of its accuracy and precision. Instrumental limits, the matter of possible extraneous lead contaminants on the subject of analysis, the labware, the in-the-laboratory environment, the reagents, *etc.* must all be considered.

Factors influencing the integrity of lead determinations in the clinical laboratory, from sample collection to interpretations of analytical results with confidence, will be discussed.

Rapid homogenization and drying of biological material, I. Y. Donev, *SP422*, pp. 721-726 (Aug. 1976).

Key words: biological materials; homogenization; lyophilization; noncontaminating; sample preparation.

The determination of chemical trace elements in biological material presents many methodological difficulties. The most important difficulties of the sample's homogenization and enrichment are connected with the elimination of contamination with other elements or losses of the latter. Another problem is tissue lyophilization.

The paper describes the procedure for a relatively rapid drying and fine homogenization of biological materials for trace element research by means of nondestructive neutron activation analysis. Data are given on a double homogenizer and vacuum drying installation at liquid

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nitrogen temperatures. Wet homogenization of tissues is carried out in the inner homogenizer. This homogenizer is put into a second one, the lower part of which is utilized for fine mincing.

Each homogenizer has a capacity of up to 15 cm^3. The humidity taken away during the drying is approximately 78 to 90 percent, and depends especially on the tissue state.

The procedure was applied with success on serum, blood, plasma and other biological materials.

The total installation allows the simultaneous drying of 13 homogenates. The total time for the drying and homogenization of 13 samples carried out by one trained laboratory assistant, is about 6 to 7 hours.

Problems in trace analysis of nitrosamines in foodstuffs, E. A. Walker and M. Castegnaro, *SP422,* pp. 727-736 (Aug. 1976).

Key words: carcinogens; food; nitrosamines; trace analysis.

Methods in general use are briefly reviewed. Epidemiological research in the region of the Caspian Littoral has demonstrated certain trends in the distribution of incidence of oesophageal cancer. Samples of typical foodstuffs from both high and low incidence areas have been analyzed for traces of N-nitrosamines. After extraction from the food, the nitrosamines were analyzed by oxidation to nitramines which were then separated by adsorption chromatography and determined by gas chromatography, using an electron capture detector. Initial results suggested a correlation between levels of nitrosodimethylamine and oesophageal cancer incidence. However, the presence of nitrosamines could not be confirmed by mass spectrometry. As a result, the clean-up procedure was modified by inclusion of a further adsorption chromatography stage when some interfering material was eliminated and all levels of nitrosamine were reduced below the 1 $\mu g/kg$ level. The work demonstrates that even for screening analysis, clean-up procedures must be rigorous when carrying out trace analysis to avoid misleading results.

Effects of storage conditions on residues of 2,4-D and 2,4-DCP in potatoes, D. Bristol, *SP422,* pp. 737-745 (Aug. 1976).

Key words: gas chromatography; potatoes; residues, dissipation of; residues, in potatoes; residues, metabolic; residues, total; residues, volatilization; storage effects; 2,4-dichlorophenol; 2,4-dichlorophenoxyacetic acid.

Red potatoes grown in North Dakota are treated with low dosage rates of 2,4-D (2,4-dichlorophenoxyacetic acid) at tuber set to improve market quality and yield. Tuber residues of 2,4-D and 2,4-DCP (2,4-dichlorophenol) in potatoes treated at a total rate of 2 ounces of active ingredients per acre were found to range from 0.068 to 0.15 and from less than 0.002 to 0.012 ppm, respectively. Samples were analyzed both with and without an acidic tissue hydrolysis step which preceded solvent extraction to determine total and free residue levels, respectively. Conjugated residues of 2,4-D could not be detected in significant quantities.

The stabilities of 2,4-D and 2,4-DCP in stored samples were found to be very dependent upon both the manner in which field samples were processed and the temperatures used for storage. Residue levels of metabolically incorporated 2,4-D in treated potato samples stored whole at 4 °C decreased over a period of 15 months to less than 0.005 ppm but those of 2,4-DCP remained constant. The observed dissipation rate of 2,4-D was approximately first order with a half-life of about 10-14 weeks. In contrast to these results, obtained under conditions used for commercial storage, the stabilities of 2,4-DCP were reversed in tuber samples which were sliced, fortified and processed immediately after harvest and stored at − 20 °C. Recoveries of 2,4-D from frozen samples were constant over a 15-month period, but those of 2,4-DCP decreased slowly from 88 to 47 percent. These contrasting results point out the utility and necessity of incorporating dissipation experiments into residue studies conducted on samples stored for significant periods of time.

Sampling problems in the investigation of high purity metals, M. Radwan, L. Walis, and H. Jaskólska, *SP422,* pp. 747-755 (Aug. 1976).

Key words: high purity metals; inhomogeneity; microsegregation; sampling; surface contamination.

One of the vital problems in the determination of trace elements in metals is their inhomogeneous distribution in the matrix. Elements which dissolve in the metal matrix at elevated temperatures often concentrate during the crystallization process at the grain boundaries, or inside the grain. Elements which do not dissolve occur in the form of non-metallic inclusions. The distribution of such inclusions is generally irregular, and obtaining results which are representative for the whole ingot is practically impossible. The error involved can be reduced, if the type and range of segregation of the element to be determined in the alloy is known and taken into account on sampling. Several examples are given.

Analytical methodology for accurate determination of trace constituents in highly pure materials, P. Albert, *SP422,* pp. 759-772 (Aug. 1976).

Key words: contamination; gas analysis; high purity; materials analysis; neutron activation analysis.

High purity materials analysis is a difficult problem and different analytical methods are used. This paper is devoted to the discussion of the principles of analytical methodology in two ways: 1. the accurate determination of one or a few trace elements in a high purity material, and 2. the accurate determination of the "complete analysis" in a high purity material with the purpose of defining the true number of "nines," at the level of six or seven "nines," in the conventional definition in percent purity. In the first case the ultimate goal of analytical measurement is a numerical result of known accuracy. The necessary conditions for the accurate and precise analytical determination of an element in a high purity material are discussed and the calibration, the "blank" and the "clean rooms," surface contamination, chemical recovery, and finally the need of certified purity reference materials are debated. In the second case the main problem is to make a selection of some complementary multielement trace analysis methods.

Discussion includes identifying and resolving the problems and identifying what areas require further research. Conclusions are made on general philosophy and attitude concerning the necessity of a general approach to guarantee the accuracy of trace analysis.

Analytical methodology—rocks and ores, H. Onishi, *SP422,* pp. 773-790 (Aug. 1976).

Key words: accuracy and precision; comparison of trace analytical methods; contamination; rocks and ores; sample preparation; trace element analysis.

To Goldschmidt we owe early knowledge of trace element geochemistry. He analyzed a variety of geomaterials by emission spectrochemical analysis during 1930-37.

Colorimetric (spectrophotometric) procedures have been developed beginning with Sandell since 1936. Studies in trace element geochemistry have been greatly advanced by means of neutron activation analysis since approximately 1950. Isotope dilution mass spectrometry is gaining a central position as a reliable trace element analysis method; this has become possible through scrupulous control of blanks.

The blank can be related to the constituent in question and the interfering (positively or negatively) substances. Correction for contamination during sample preparation is usually very difficult. The blank is affected by reagents, vessels, and atmosphere or environment, all of which require the close attention of the analyst. Ways for reducing blank values are briefly mentioned.

Methods recently described for determination of trace elements in geomaterials are: spectrophotometric and fluorimetric, emission spectrochemical, atomic absorption and flame emission, x-ray fluorescence, nuclear (activation, nuclear track, *etc.*), electrochemical, mass spectrometry, and gas chromatography. Examples of comparison of methods are given. The following are to be considered in choosing the proper analytical technique: objective of analysis, sensitivity and detection limit, accuracy, precision or reproducibility, determination of single element or multielements, time and cost, and analyst.

The past, present, and future of the analysis of atmospheric particulates, R. K. Skogerboe, *SP422,* pp. 791-803 (Aug. 1976).

Key words: atmospheric particulates; direct analysis techniques; emission spectroscopy; particulate analysis; particulate characterization; sampling methods; X-ray fluorescence.

The determination of the composition of airborne particulate matter is a major task of escalating importance. The general requirements imposed on the analytical methods are typical: The multielement composition must be determined accurately and precisely over a wide concentration range. These accurate results are to be generated by the analytical method even though there may be major variations in the general composition of the particulate samples or in their "preparative" histories. Other emerging requirements include the determination of composition on a continuous basis in the field even at exceedingly low concentrations and/or the specification of composition as a function of particle size.

A comparative evaluation of the various analytical methods used for characterization of particulates is presented from the perspective of these requirements. The state of the art for several competitive analytical methods is summarized and their advantages and limitations defined. A synopsis of ongoing research is presented and potentially fruitful directions for analytical development are indicated.

Analytical chemistry of natural waters, D. E. Robertson, *SP422,* pp. 805-836 (Aug. 1976).

Key words: accuracy; analytical chemistry; contamination; errors; natural water; sample storage; sampling.

Analysts who have had more than a casual experience in trace element analysis of natural waters will unanimously agree that achieving accurate and precise results is indeed a difficult task. The reasons for these difficulties are numerous and begin with the collection of the sample. Many of the factors which govern the accuracy and precision attainable by present techniques and instrumentation for the measurement of trace element analysis of waters, from the sampling through the actual analysis, are discussed. Several case studies are presented which illustrate the parameters which must be carefully evaluated to ensure sufficient accuracy and precision in water analysis.

Analytical methodology for accurate analysis in clinical chemistry, S. S. Brown and F. L. Mitchell, *SP422,* pp. 837-850 (Aug. 1976).

Key words: accuracy; clinical analysis; clinical chemistry; health; precision.

Methods of measurement in clinical chemistry need to be continuously assessed to determine the degree of accuracy and precision required to ensure their optimum value for clinical purposes. Constant review is necessary since improvements in technology often show that much of what was once thought to be biological variation within and between individuals can be laboratory error. When biological variation is clearly known, it is pointless to provide measurements which may be costly when done beyond the required degree of accuracy and precision. In many cases however, that degree is not yet attainable in routine work.

Once determined, these levels of efficiency must be maintained and comparability of results ensured between laboratories and nations. Only comparatively recently have the principles which are required to achieve this, been formulated and understood. The first stage was the elimination, as far as possible, of human error by the large-scale introduction of automation and electronic data processing, then when precision was thus brought under control, it became possible to investigate accuracy.

Work in this direction using special reference technology, is proving that many of the well established techniques are far from satisfactory. New substances are required to be measured increasingly, and often, a technique may be accurate and not precise or *vice versa,* only an ability to monitor and maintain accuracy and precision with confidence in the clinical chemistry laboratory, will ensure continued progress in the use of clinical measurement in medicine. Ways of doing this will be discussed.

Trace level determination of triclosan by gas chromatography, F. H. Marquardt, J. Schulze, and D. Smith, *SP422,* pp. 851-859 (Aug. 1976).

Key words: bacteriostats; blood analysis; gas chromatography; trace analysis; triclosan; 2-hydroxy-2′,4′,4-trichlorodiphenyl ether.

The triclosan (2-hydroxy-2′,4′,4-trichlorodiphenyl ether) content in various substrates, for example, blood, can be determined by extraction into hexane, formation of the acetyl derivative, and gas chromatography over OV-17 with an electron capture detector, either with or without aldrin as internal standard. The precision and accuracy of this method is discussed.

Electrochemical trace analyses based on Faraday's Law, D. J. Curran, *SP422,* pp. 861-869 (Aug. 1976).

Key words: automatic titrations; coulometric titrations; current integration; digital timing; epinephrine; linear sweep voltammetry; manganese; micrometer cell; thin layer electrochemistry; vanadium.

Thin layer electrochemical measurements and constant current coulometry can provide useful absolute methods for trace analysis.

The difficulty to distinguish the coulombs consumed by the Faradaic process from the total coulombs consumed in

the experiment can be minimized by the use of a null concept with constant current coulometry. After adjustment of the system to the null point, for example potentiometric, the sample is added and the system returned to the null by coulometric titration. The electrochemical potential of the system is the same before and after passage of the electrolysis current, no charge can be lost or gained from charging or discharging of the double layer. Several examples of determinations based on this concept are presented.

The coulometric method involves the use of an electrogenerated titrant in almost all cases. A more direct approach to the use of Faraday's Law is provided by thin layer methods, where direct electrochemical conversion of the species of interest is carried out stoichiometrically. Corrections for background coulombs must be made with these techniques. Very small volumes of solutions as dilute as $10^{-5}M$ can be handled and several examples are presented. In addition, it is possible to combine thin layer methods with electrochemical preconcentration techniques to yield a versatile tool for trace analysis.

The non-faradaic background in pulse polarography, R. A. Osteryoung and J. H. Christie, *SP422,* pp. 871-879 (Aug. 1976).

Key words: background correction; differential pulse polarography; dropping mercury electrode; electroanalysis; pulse polarography; trace analysis.

The dropping mercury electrode, with its continually renewed fresh surface, offers advantages for real sample analysis. However, continuous expansion of the electrode drop requires a continuous non-faradaic current to maintain the charge density on the electrode surface. The techniques of pulse polarography attempt to minimize this non-faradaic component by differencing currents flowing before and after application of a potential step to the drop. Nevertheless, since these currents are measured neither at the same potential nor at the same time in drop life, the difference current will contain a non-faradaic contribution, which is a *nonlinear* function of a potential.

Extensive computer simulations of the effect of the non-faradaic background on the analytical utility of pulse polarography at trace concentrations indicate that inaccurate results may be obtained if the true baseline is not known (as is likely for a real matrix). The magnitude of the background limits the amount of analyte that may be detected and the nonlinearity of the background determines the accuracy with which the superimposed faradaic signal may be measured.

Recognizing that the double layer charging current is dependent only on the potential and the time in drop life at which the current is measured while the faradaic current depends on the history of the entire drop, we have devised three variants of pulse polarography which compensate for the non-faradaic background current. These variants of pulse polarography are: 1. alternate drop pulse polarography. The output current is the difference in current for a drop whose potential is changed late in drop life and a drop maintained at the step-to potential throughout its life. 2. Twin electrode pulse polarography. The current output is the difference in current between two matched drops, both in the test solution, one of which is pulsed while the other is maintained at the step-to potential.

Improved anodic stripping voltammetry for accurate trace analysis, M. Ariel and J. Wang, *SP422,* pp. 881-897 (Aug. 1976).

Key words: anodic stripping voltammetry; background current compensation; differential anodic stripping voltammetry; electrochemical analysis; twin electrode balancing.

The unfavorable "signal to noise" ratio obtained during measurements carried out in very dilute metal ion solutions sets the lower concentration limit in anodic stripping voltammetry (ASV) determinations. The noise, deriving largely from the background current during the stripping step, is composed of a capacity current and a faradaic current contribution. DASV (differential ASV) and ASWC (anodic stripping with collection), carried out with *in situ* mercury film formation at rotating glassy carbon disc or ring-disc electrodes respectively, efficiently reduce residual current interference and significantly improve the reliability of ASV methods, as applied to real sample analyses.

DASV is carried out at identical twin working electrodes balanced against each other and immersed in the sample solution, to which Hg^{+2} ions have been added. Preelectrolysis, carried out at both electrodes at the same potential but for different deposition periods, is followed by a stripping step during which the oxidation currents are substracted.

In ASWC, a rotating ring disc electrode is employed; conventional ASV at the disc is supplemented, during the stripping step, by simultaneous redeposition at the ring, kept at a suitably cathodic constant throughout the stripping scan, allowing unequivocal quantitative evaluation of collection current peaks. Very rapid scan rates may be employed during the disc stripping steps, resulting in improved sensitivity without any loss in accuracy.

The method, combined with thin film ASV, with the mercury film co-deposited *in situ* with the trace metals present on a glassy carbon ring disc electrode, yields excellent results in the analysis of trace metal solutions in the ppb (and lower) range.

Monitoring dissolved copper in seawater by means of ion-selective electrodes, G. K. Rice and R. J. Jasinski, *SP422,* pp. 899-915 (Aug. 1976).

Key words: adsorption; copper; cupric ion; flow cell; ion-selective electrode; seawater analysis.

The application of an ion-selective electrode method for continuously monitoring Cu^{++} in seawater, without sample pretreatment, is described.

The necessary sensitivity of the Cu^{++} selective electrodes was achieved by preconditioning the electrodes and by use of a flow cell configuration. Response times, even at trace concentrations, were found to be adequate for monitoring small changes in the Cu^{++} concentration of seawater.

Evaluating the effects of solid materials on the chemistry of Cu^{++} in seawater was simplified by the speed and convenience of the ion-selective electrode technique. In addition to the adsorption of metal ions on solid surfaced, Cu^{++} electrode analysis indicated that contaminants from some solid materials form complexes with Cu^{++} in solution. Other materials apparently introduce cations such as Fe^{+++} which can liberate Cu^{++} from some complexes. It was also found that changes in chemical properties such as pH measurably affect the distribution of Cu^{++} in seawater.

Operation of a trace sampling and analysis system aboard a ship is complicated by chemical and electrical effects of the ship's hull on the continuous seawater flow stream. A method was found for minimizing electrical "noise" in the flow stream and to distinguish the Cu^{++} potential of chemical contamination due to the ship from the ambient background of natural seawater.

The results indicate that it should be practical to develop trace analytical methods which require little or no sample

pretreatment for true *in situ* analysis thus avoiding many of the problems of sampling and sample handling.

Electroanalytical determination and characterization of some heavy metals in seawater, M. Branica, L. Sipos, S. Bubic, and S. Kozar, *SP422*, pp. 917-928 (Aug. 1976).

Key words: Adriatic Sea; cadmium; copper; electrochemical analysis; heavy metals; lead; seawater analysis; speciation; stability of water samples; zinc.

Anodic stripping methods have been widely applied during the last 10 years for determination of some heavy metals in natural water systems. However, relatively little has been done on the physicochemical characterization and determination of species actually present in aquatic systems, which is of special importance for elucidation of respective biogeochemical cycle and fate of radioactive or industrial waste.

The experience on application of electroanalytical techniques is presented and discussed with regard to: 1) direct determination of concentrations of some metal ions; 2) characterization of the species actually present; 3) study of chelation, hydrolyzation and other interactions between metallic ions and organic ligands in natural aquatic system.

Anodic stripping voltammetry (ASV) with rotating glassy carbon electrode was used for determination of Cd, Pb, and Cu and slowly dropping mercury electrode was used for determination of Zn in the North Adriatic. The reproducibility of measurements, behavior of electrodes, the role of cell and storage bottle materials and sampling procedures are discussed.

A new method for characterization of the ionic state of metals at very low concentrations (10^{-9} to $10^{-8}M$), based on voltammetric measurements with accumulation at various constant potentials, is proposed.

The accurate determination of lead in biological and environmental samples by isotope dilution mass spectrometry, L. A. Machlan, J. W. Gramlich, T. J. Murphy, and I. L. Barnes, *SP422*, pp. 929-935 (Aug. 1976).

Key words: accurate and precise analysis; biological and environmental samples; blanks; homogeneity of lead content; isotope dilution mass spectrometry; lead analysis.

The accurate determination of lead in biological and environmental samples has become of great interest due to health considerations. Isotope dilution mass spectrometry (IDMS) has proven to be precise and accurate to within 0.15 percent. The IDMS method has permitted the accurate determination of trace quantities of lead in samples of biological and environmental interest as well as determining the inhomogeneity of the lead content.

IDMS has been utilized to provide certified lead values in Standard Reference Materials used by the fuel industry (coal, fuel oil and fly ash). These materials are to be used for comparison standards, quality assurance and developing or verifying analytical methods. The lead content of a series of blood samples has also been determined by IDMS to provide accurate values in the development of a clinical reference method.

The method consists of taking a weighed aliquot of the sample, adding a known amount of separated isotope, decomposing the material with suitable acids, separating the lead by anion exchange, purifying the lead by electrodeposition, determining the lead isotope ratios by thermal ionization mass spectrometry and calculating the lead content of the sample.

Rare earth element analysis by isotope dilution, G. N. Hanson, *SP422*, pp. 937-949 (Aug. 1976).

Key words: analytical techniques; fractional crystallization; geochemistry; isotope dilution; partial melting; rare earth elements; trace element models; volcanic rocks.

At Stony Brook we have been analyzing igneous rocks, granites through gabbros, basalts, and ultramafic rocks for rare earth elements (REE) as well as the other major, minor, and trace elements in order to determine the origin of these rocks utilizing quantitative trace element models. For rare earths we are using the analytical procedure of J. G. Arth, USGS, Reston, Virginia, which utilizes two Dowex 50Wx8 cation columns, one for nitric acid to get a group separation of the REE and the other for hydrochloric acid to separate the specific REE. The rare earth elements La, Ce, Nd, Sm, Eu, Gd, Dy, Er, Yb, and Lu can usually be analyzed in three to four mass spectrometric runs with a total time for analysis of about 8 hours. The number of REE analyzed should not be reduced or the great advantage of the REE, the regular but not consistent variation from element to element, cannot be fully utilized in an interpretation. Precision is about 1 percent for all elements except for Lu and Gd. The uncertainty in the accuracy is somewhat greater.

Much of the REE data in the literature has uncertainties of about 5 percent or greater, and for gross comparison of rock types this data is adequate. REE data, however, with uncertainties much greater than 10 percent are no longer acceptable, as they are not useful even for gross comparisons of rock types.

In a detailed study of a magmatic sequence in order to distinguish differentiated fractions *versus* different original parents and to determine which residual or fractionating minerals are involved, then high precision on the order of 1 percent is absolutely necessary. In such a sequence, since it is only necessary to compare samples with each other, high precision is adequate as one can normalize all samples to a sample in the sequence. In order to compare data with other laboratories, however, high accuracy is also necessary. The uncertainty in the accuracy is mainly in not having adequate rare earth standards.

An accurate determination of electrolyte concentrations in blood serum by isotope dilution mass spectrometry, E. L. Garner, L. A. Machlan, J. W. Gramlich, L. J. Moore, T. J. Murphy, and I. L. Barnes, *SP422*, pp. 951-960 (Aug. 1976).

Key words: accurate; blood; concentrations; determination; dilution; electrolyte; isotope; mass spectrometry; serum.

Concentrations of the electrolytes Li, Mg, Cl, K and Ca were determined in three different lots of blood sera by isotope dilution mass spectrometry. Descriptions of the chemistry, mass spectrometry, and some of the precautions necessary to obtain an accurate measurement are given. An internal normalization technique which eliminates a systematic bias component due to variable isotopic fractionation between different analyses, was used to significantly improve the accuracy of the magnesium measurement. The experimental values for the three lots of sera followed a pattern of low, intermediate and high concentration levels for each electrolyte. The magnesium values in $\mu g/g$, for example were 8.546 ± 0.064, 24.52 ± 0.08, and 41.27 ± 0.10. The estimated limit of error for a single analysis, based on the 95 percent confidence limit and the effect of sample impurities, ranged from 0.75 percent for magnesium in one lot of serum to 0.2 percent for the potassium concentrations.

Spiking isotope dilution and its application to fluorine determinations, H. A. Das and T. Wals, *SP422*, pp. 961-982 (Aug. 1976).

Key words: absorption isotherm; environmental samples; fluorine; isotope dilution; radionuclides; substoichiometry.

Isotope dilution is based on the isolation of a constant substoichiometric amount. This method can be completed by a group of techniques in which this amount is a function of the concentration to be determined. This approach enables the routine analysis of aqueous samples. The practical difference with normal isotope dilution is twofold: a) the activity is added as a spike to both the standard and the sample solution and b) the count rates obtained for the fractions isolated from the standard solutions, are plotted against the concentration in such a way that a linear calibration curve is obtained. Some methods which can be used in the application of this principle are discussed and compared to "classical" isotope dilution. Expressions are derived for the relative statistical error and the limit of detection. As a practical example of these techniques, the determination of fluorine is discussed. The radionuclide used is ^{18}F (T 1/2 = 110 min), which is prepared carrier free by irradiation of Li_2CO_3. The substoichiometric amount is taken by either absorption on glass beads or by imperfect liquid-liquid extraction with $(CH_3)_3SiCl$ dissolved in benzene. The glass beads or the organic extract are counted integrally. The reciprocal of the count-rate is a linear function of the concentration to be determined. The limit of detection is usually 0.01 μg/ml, while the limit of determination is $\simeq 0.05$ μg/ml. The method is applicable to both F^- and $SiF_6^=$ and is not sensitive to appreciable NaCl concentrations. The error is depending on counting statistics and on the ratio reagent amount to be determined. The method can be extended to dried plant material by ashing and dissolving the sample, using ^{18}F-tracer for chemical yield determination.

The determination of small amounts of nitrogen (0 to 20 ppm) in plain carbon steels, H. F. Pronk, J. de Boer, and N. Butter-Bijwaard, *SP422*, pp. 983-1003 (Aug. 1976).

Key words: atmospheric contamination; blank value; indophenol blue reaction; Kjeldahl digestion technique; limit of detection; nitrogen in steel.

The paper describes the results of a thorough experimental investigation into the original and reduction of the blank during sample handling and sample analysis in the determination of the total nitrogen content in plain carbon steels at levels of 0.002 percent and less. Attention is paid to atmospheric contributions to the blank and to their prevention. The possible harmful effect of nitrite or nitrate compounds on the analytical result is pointed out. Finally a method is recommended which is especially adapted for the determination of very low levels of nitrogen.

Trace element analysis of nickel and nickel-base alloys—a review of current methods, C. M. Davis, *SP422*, pp. 1005-1016 (Aug. 1976).

Key words: atomic absorption spectrophotometry; emission spectroscopy; nickel; nickel-base alloys; polarography; spectrophotometry; x-ray fluorescence spectroscopy.

Trace element analysis has been a frontier in the field of analytical chemistry for many years. Twenty years ago 0.01 percent was considered a "trace." Today, specifications require certain nickel-base alloys to have no more than 0.00003 percent (0.3 ppm) of some elements. The everchanging definition of the word "trace" has made trace element analysis a continuing challenge to the analytical chemist. This paper reviews the various approaches to this elusive problem and outlines potential solutions. The emphasis is on elements categorized as being detrimental to the mechanical properties of nickel-base alloys since these are of the greatest concern.

Among the methods reviewed are spark source mass spectrometry, emission spectroscopy, x-ray fluorescence spectroscopy, spectrophotometry, polarography, and atomic absorption spectrophotometry.

Nonuniform distribution (both micro and macro) of trace elements in high-temperature alloys, O. H. Kriege and J. Y. Marks, *SP422*, pp. 1017-1022 (Aug. 1976).

Key words: high-temperature alloys; intergranular segregation; macro-segregation; sampling problems; trace elements.

Because low melting metals such as bismuth, lead, selenium, tellurium and thallium can have a harmful influence on the mechanical properties of high-temperature alloys, the accurate determination of 0.3 to 10 ppm of these metals is of considerable importance. In developing reliable methods for the determination of trace elements in complex, high-temperature alloys, major sampling problems were encountered. Significant variations in trace metal concentrations were frequently noted in different parts of the same casting. For example, marked variations were sometimes observed between the top and bottom of small cast parts, other specimens had significantly different amounts of trace metals at the surface than at the center of the coating, while the concentration of certain trace metals was a function of wall thickness in some hollow parts. The common practice of sample selection by removal of material from noncritical regions of a casting to preserve the part can evidently lead to serious errors in cases when macro-segregation of trace elements exists. Various production practices which have produced analytically important macro-segregation are summarized in detail.

In addition to macro-segregation, significant intergranular segregation has been observed in high-temperature alloys. There is a pronounced tendency for certain trace elements to concentrate at grain boundaries rather than at the center of grains. With the increased commercial importance of directionally solidified and other large grain cast materials, the importance of this micro-segregation is increased, particularly when methods are used which involve the analysis of very small amounts of sample. Techniques for proper sampling of nonuniform, high-temperature alloys are reviewed.

In addition, those methods which are currently used to determine low concentrations of trace metals in high-temperature alloys are reviewed.

Monitoring of an atomic absorption spectrophotometer using cumulative sum statistical control charts, J. R. Montgomery, *SP422*, pp. 1023-1033 (Aug. 1976).

Key words: atomic absorption; cadmium; copper; lead; manganese; sensitivity; spectrophotometry; statistical methods; zinc.

A method has been devised to monitor the reproducibility of an atomic absorption spectrophotometer utilizing statistical control charts. Standard curves for five elements, Cu, Pb, Zn, Mn, and Cd have been monitored to determine if the cumulative sum type control charts with "V" mask can detect incipient changes in sensitivity of the atomic absorption spectrophotometer caused by alteration in lamp output, fuel, air mixtures and electronic gear. The cumulative sum chart

is easily computed and allows the operator to quickly detect significant changes in the sensitivity of the machine.

Signal characterization and measurement in microsample atomic absorption spectrometry, R. S. Vogel and A. M. Hartley, *SP422*, pp. 1035-1043 (Aug. 1976).

Key words: atomic absorption; background correction; Delves Cup; lead; spectrophotometry.

Some of the errors encountered in atomic absorption spectrometry are broadband absorption due to light scattering by particles and absorption by molecular species originating from the sample matrix. Instrumentation for microsample techniques have been developed for typical volumes of 50 μl or less. The resultant transient absorbance signals are from one to several orders of magnitude greater than the same concentration in the 1-ml or more sample volume typically required by conventional solution aspiration methods. Background signals associated with the microsample methods are sometimes a major fraction of the total absorption signal. Literature dealing with these methods has emphasized the ubiquitous nature of background absorption and so-called "smoke" peaks. Specific absorption by atomic species might be mistaken for nonspecific background absorption resulting in significant errors. An example is given of this potential problem and how mistakes can be avoided.

Absorption signals characteristic of those from nebulizer-burner systems, as well as those from microsample systems are discussed. The conclusion drawn on the basis of the experimental evidence is not that the "smoke" peak attributed by others to nonspecific absorption is actually due to atomic absorption, but rather, when in the use of the microsample atomic absorption techniques, sequential absorption peaks are observed. Each of these peaks must be studied objectively or serious analytical errors may occur.

An intercomparison of flame and nonflame systems in atomic absorption spectrometry, T. C. Rains and O. Menis, *SP422*, pp. 1045-1051 (Aug. 1976).

Key words: atomic absorption spectrometry; nonflame graphite furnace; sensitivity *vs.* precision and accuracy; Standard Reference Materials.

In atomic absorption spectrometry (AAS) the nonflame devices for producing atomic vapor have recently received wide attention. In comparison to the traditional flame technique they offer increased sensitivity for many elements. On the other hand they seemed to suffer from poorer precision. In this study several of the parameters affecting the precision of the carbon furnace were evaluated and data were compared with NBS Standard Reference Materials (Fly Ash, Coal, and Orchard Leaves). Operating conditions, such as the sample volume, and the temperatures of the drying, ashing and atomization controlled the precision and accuracy of the measurement. The main advantage of the graphite furnace was the elimination of the preconcentration step and its inherent problem of larger blanks.

Atomic absorption spectrophotometry of air filter paper tape samples, F. J. Muñoz-Ribadeneira, M. L. Nazario, and A. Vega, *SP422*, pp. 1053-1061 (Aug. 1976).

Key words: air sampling; atomic absorption spectrophotometry; high temperature ashing; trace elements.

Several techniques for the preparation of air paper tape samples for trace metal analysis by Atomic Absorption Spectrophotometry (AAS) have been investigated. Known amounts of Cr, Mn, Co, Ni, Cu, Zn, Cd, and Pb were used to study the recovery of each under the effects of several preparative and digestion procedures. Conclusions obtained by means of a statistical analysis of the results are given. Statistical analysis of data obtained from the application of the most successful techniques when applied to natural air particulate samples are also presented.

Analysis of cadmium in fish tissue by flameless atomic absorption with a tantalum ribbon, E. R. Blood and G. C. Grant, *SP422*, pp. 1063-1072 (Aug. 1976).

Key words: atomic absorption; bluegills; cadmium; fish; heavy metal; tissue; trace element analysis; water pollution.

Bluegills *(Lepomis machrochirus)* of the same age and approximately the same size after acclimation were exposed to known amounts of cadmium (ppm level), sacrificed at selected time intervals and frozen whole in plastic bags until dissection and analysis. The heart, liver and kidney were removed entirely and portions of skin, muscle, gill, gut and bone were taken at the same time. Analyses were made by atomic absorption, following wet digestion in concentrated acid. All results are expressed as micrograms cadmium per gram of wet tissue. Typical values reported are in the range of 0.2 to 20 μg Cd per gram of wet tissue with a typical precision of 10-15 percent rsd for repetitive aliquots from the same organ. Corresponding organs from different fish, however, gave mean values differing from one another by as much as a factor of five.

Methodological considerations in western Lake Superior water-sediment exchange studies of some trace elements, J. E. Poldoski and G. E. Glass, *SP422*, pp. 1073-1088 (Aug. 1976).

Key words: anodic stripping voltammetry; flameless atomic absorption; interstitial water; Lake Superior chemical analysis; trace element water analysis; water filtration; water sampling apparatus.

Trace element measurements on western Lake Superior water were taken as a function of geographical area and distance above and below the water-sediment interface. The objective of detecting gradients of certain constituents in the system, however, required an extensive examination of required methodology. Investigations of this methodology indicate that the values obtained from a particular sample type are constrained by a number of uncertainties and operational definitions. Data were taken using different methods and experiments were conducted at various points in the analytical scheme to determine the influence of sample collection, handling and analysis steps. Results were of aid in determining where emphasis should be placed to improve the end result.

Accuracy in determining trace element concentrations in marine sediments, E. D. Wood and N. A. Cintron, *SP422*, pp. 1089-1102 (Aug. 1976).

Key words: accuracy; Atomic Absorption Spectrometry; Caribbean; precision; Puerto Rico; replicates; sediments; standard; trace elements.

When sampling the environment, one desires not only an accurate analysis of a particular sample, but also an analysis which is representative of the region sampled and one that can be repeated within reasonable limits. Replicate sediment samples were collected in the course of mapping a portion of the sea floor on the west coast of Puerto Rico. The location is in the discharge region of the Guanajibo River. Ten replicate grab samples were taken by independent positioning of the ship. The samples were stripped with hydrochloric

acid and the resulting solutions analyzed by atomic absorption spectrometry (AAS) for Ca, Cd, Co, Cr, Cu, Fe, Mg, Ni, Pb, Sr and Zn. The standard deviations of replicate analysis of individual samples were generally less than for the individual samples themselves. Chemical standards prepared in our laboratory were used to determine the value of the samples. Particle size and homogeneity are factors considered with respect to the number of replicates required and sample size. The average concentrations for several elements in a set of 10 samples with confidence limits for 95 percent level as determined by AAS are as follows: Cd, 0.840 ± 0.011; Co, 56.5 ± 0.2; Cr, 696 ± 8; Cu, 30.7 ± 0.4; Fe, 60000 ± 1010; Mn, 827 ± 5; Ni, 487 ± 5; Pb, 17.2 ± 0.2; and Zn, 70.3 ± 0.8 μg/g dry sediment. A composite sample from this location was prepared for use as a standard in future sediment analysis.

Significant improvement of accuracy and precision in the determination of trace rare earths by fluorescence analysis, L. Ozawa and H. N. Hersh, *SP422*, pp. 1103-1107 (Aug. 1976).

Key words: fluorescence method analysis; rare earths, as an internal reference; rare earths, determination of trace amounts.

Most of the rare earths in yttrium, gadolinium and lanthanum oxides emit characteristic fluorescent line spectra under irradiation with photons, electrons and x rays. The sensitivity and selectivity of the rare earth fluorescences are high enough to determine the trace amounts (0.01 to 100 ppm) of rare earths. The absolute fluorescent intensities of solids, however, are markedly affected by the synthesis procedure, level of contamination and crystal perfection, resulting in poor accuracy and low precision for the method (larger than 50% error). Special care in preparation of the samples is required to obtain good accuracy and precision.

It is found that the accuracy and precision for the determination of trace (less than 10 ppm) rare earths by fluorescence analysis is improved significantly, while still maintaining the sensitivity, when the determination is made by comparing the ratio of the fluorescent intensities of the trace rare earths to that of a deliberately added rare earth as reference. The variation in the absolute fluorescent intensity remains, but is compensated for by measuring the fluorescent line intensity ratio. Consequently, the determination of trace rare earths (with less than 3% error) is easily made by a photoluminescence technique in which the rare earths are excited directly by photons. Accuracy is still maintained when the absolute fluorescent intensity is reduced by 50 percent through contamination by Ni, Fe, Mn or Pb (about 100 ppm). Determination accuracy is also improved for fluorescence analysis by electron excitation and x-ray excitation. For some rare earths, however, accuracy by these techniques is reduced because indirect excitation mechanisms are involved. The excitation mechanisms and the interferences between rare earths are also reported.

The advantages of x-ray fluorescence analysis for trace elements in silicate rocks, B. M. Gunn, *SP422*, pp. 1109-1118 (Aug. 1976).

Key words: mineral analysis; trace analysis; x-ray fluorescence.

X-ray fluorescence (XRF) analysis has been successfully used to analyze over 1000 rock, cement and ore samples per year for elements including F, Na, Mg, Al, Si, P, S, Cl, V, K, Ca, Ti, Mn, Fe, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Ba, Cs, Ce, La, Pb, Th, and U. Detection limits are never greater than 10 ppm and optimally are as low as 1 ppm for 60 second counting times. Accuracy is mainly limited by the accuracy of available standards which for major and minor elements are not known to better than 0.1 to 0.01 percent. Data reduction and matrix corrections are made by computer and programs have been developed in both FORTRAN IV and FOCAL-11 language.

Monitoring of smog aerosols with elemental analysis by accelerator beams, T. A. Cahill, R. G. Flocchini, R. A. Eldred, P. J. Feeney, S. Lange, D. Shadoan, and G. Wolfe, *SP422*, pp. 1119-1136 (Aug. 1976).

Key words: aerosol; California aerosol monitoring program; elemental analysis; ion beam analysis; monitoring; particle sizing; time resolution.

The California Air Resources Board has operated an aerosol monitoring network of up to 15 stations since January 1973, using impactors to collect size segregated samples and ion-excited x-ray emission to perform the subsequent elemental analyses. Two-stage Lundgren-type rotary drum impactors with afterfilters collect particles in the 0.1 to 0.6 μm, 0.6 to 5 μm, and 5 to 20 μm size ranges. Alpha beams from an isochronous cyclotron, possessing energies of 18 MeV, are used to excite x-rays in the aerosol samples, which are then detected by a Si(Li) x-ray detector. On-line data collection and reduction codes generate aereal densities for elements between sodium and uranium, with sensitivities in the nanogram per cubic meter range for most elements. During the first year of operation, about 12,000 analyses were performed as part of this program. Each analysis normally included between 15 and 25 elements. In order to insure that all results were accurate, extensive programs were undertaken in quality assurance. The first concern involved proper operation of the aerosol collection systems. Uranene dye studies were able to generate information on the particle size cuts induced by the impactor slits, as well as indicate the importance of nonoptimum collection effects such as bounce-off from the drum surfaces. However, extensive studies with real aerosols were required before the problem of bounce-off for dry, silicious aerosols was solved by coating the drums with 530 μg/cm^2 mylar upon which was deposited about 50 μg/cm^2 paraffin. Penetration of the Nuclepore final filter contributed important corrections to the smallest size range, based upon the work of Spurney and Lodge. Operation of the collection system was verified through extensive comparisons on an element by element basis with high-volume filter samplers, and a nominal collection error of $\pm$ 15 percent was assigned from these causes. Absolute accuracy of the analysis system was established through the use of 28 gravimetric thin film standards, and confirmed by numerous interlaboratory and inter-method comparisons, all of which showed that the nominal analytical accuracy of $\pm$ 10 percent was quite conservative. Major corrections for light elements, loading effects, which limited accuracy to $\pm$ 30 percent for sodium in the worst case.

Characteristics of environmental airborne fissionable material, B. M. Center, K. E. Jackson, and F. H. Ruddy, *SP422*, pp. 1132-1142 (Aug. 1976).

Key words: alpha particle tracks; fission radiography; solid dielectric track recorders; ^{239}Pu track.

Methods are reported for performing a quantitative assay of environmental air samples for fissionable material. Determination of size characteristics using the nuclear track technique is given and a comparison is made with size characteristics obtained from an aerodynamic (cascade im-

pactor) separation. Special emphasis is placed on the important problem of detection of plutonium in the environment.

Analytical design in activation analysis: The role of accuracy and precision, D. A. Becker, *SP422*, pp. 1143-1155 (Aug. 1976).

Key words: accuracy and precision; activation analysis; analytical design; irradiation procedures; radioactivity detection systems; radiochemical separations; sampling and sample handling.

In order to obtain maximum utilization of the technique of activation analysis, a logical and systematic method for the evaluation of alternate analytical procedures is required, especially for analyses requiring a high degree of accuracy and precision. The activation analysis procedure can be separated into the four basic areas: A) sampling and sample handling; B) irradiation procedures; C) radiochemical separations; and D) detection systems. Each of these areas can then be divided into a number of individual options, each option with its own characteristics, including an uncertainty value.

The resulting analytical design results when these options are fused to form a procedure which will adequately meet the requirements. This paper outlines many of the options available in each area and discusses some of their inherent limitations and uncertainties.

A search for accuracy in activation analysis of trace elements in different matrices, S. Meloni, M. T. Ganzerli-Valentini, V. Caramella-Crespi, V. Maxia, L. Maggi, U. Pisani, R. Soma, and P. Borroni, *SP422*, pp. 1157-1164 (Aug. 1976).

Key words: accuracy; activation analysis; copper; gold; hafnium; palladium; platinum; precision; radiochemical separations; silver.

Different factors may affect accuracy in activation analysis of trace elements. The evaluation of these factors often requires a number of time consuming experiments, but the statement of accuracy in activation analysis is of great value to cast some light on the overall reliability of the method itself. It can be pointed out that accuracy is often inversely proportional to the number of steps of the whole analytical procedure, from sampling to calculation of results. Several techniques of activation analysis were developed and applied to the determination of trace element content in standard reference materials and in samples chosen for intercomparison among laboratories. Emphasis was put on limiting the number of steps to improve the accuracy and on achieving the best of precision. Results are presented and discussed, together with the criteria for the choice of the most appropriate separation technique. Other sources of systematic errors, such as the reliability of the content of the reference standards and dead-time corrections when short-lived isotopes are involved, were taken into account and discussed.

Surface effects on accuracy in activation analysis, G. Revel and M. Federoff, *SP422*, pp. 1165-1171 (Aug. 1976).

Key words: accuracy; activation analysis; charged particle irradiation; diffusion; etching; metals; neutron irradiation; recoil; surface effect.

One of the main advantages of trace activation analysis is the possibility of eliminating surface contamination by post-irradiation removal of the superficial layers of the sample. In some cases this advantage is lost by noneffective removal, leading to inaccurate results. We discuss the main causes of ineffective removal of surface contamination. In neutron activation analysis the surface contamination takes place during sampling and irradiation. The main causes of ineffective removal of this contamination are redeposition during chemical etching and large diffusion during irradiation. For the determination of light elements (O,C,N) performed by charged particle or photon irradiation, the surface contamination is increased through the diffusion of impurities by recoil and channeling. Chemical etching, used as the only method, is not convenient for a number of metallic samples—often the thickness of the dissolved layer varies along the surface due to heterogeneities in purity, crystalline structure and localized oxidation made by non-homogeneous incident beam. Several examples investigated by tracer and metallographic methods are given. A procedure for accurate surface contamination removal is suggested.

A study into the accuracy of a remote-controlled system for multielement determination in foodstuffs using NAA, R. Schelenz and J. F. Diehl, *SP422*, pp. 1173-1180 (Aug. 1976).

Key words: biological material; biological standards; data evaluation; distillation; food composition; gamma spectrometry; inorganic separators; isotopic exchange; multielement determination; neutron activation; radiochemical separation; trace elements.

More accurate information on the trace element composition of foodstuffs is important in the field of nutrition. An appropriate approach to this problem is the application of neutron activation analysis for simultaneous multielement determination using high resolution gamma spectrometry.

A system has been developed permitting determination of at least 28 elements, utilizing remote controlled radiochemical processing of irradiated biological samples. The reliability of the method has been ascertained by participation in inter-laboratory comparisons organized by the International Atomic Energy Agency (IAEA). Results for multielement determinations are given for potatoes (peeled), milk powder, fish solubles and algae.

Neutron activation analysis of elements extracted into organic media, R. Stella and N. Genova, *SP422*, pp. 1181-1187 (Aug. 1976).

Key words: chlorine effect; counting corrections; gamma intensity attenuation; neutron flux depression; organic liquid sample irradiation; palladium distribution ratios; platinum distribution ratios.

It is sometimes worthwhile, especially in solvent extraction studies by radiochemical techniques, to neutron irradiate the organic phase after extraction and directly count the same. Problems arise in comparing gamma activities in the corresponding aqueous phases, eventually irradiated after extraction, and in aqueous standards. Many factors may affect, though in a different way, both the neutron activation and counting steps: the former being a function of neutron absorption in the organic medium that may be especially relevant in the case of chlorine containing solvents and of the different neutron thermalizing properties of the same.

To test these effects, tributyl phosphate in various diluents as an extractant for the chlorocomplexes of some noble metals, namely Pd, Pt, Ir, Os and Au, was used.

The effect of different thermalizing power of the media by comparing the activities of irradiated aqueous and organic samples containing same amounts of neutron absorbing elements was also evaluated.

Estimation of primary reaction interferences in fast particle activation analysis by calculations using cross section data, V. Krivan, *SP422*, pp. 1189-1214 (Aug. 1976).

Key words: accuracy; activation analysis; analytical chemistry; charged particle activation analysis; cross sections; excitation functions; fast neutron activation analysis; fast particle activation analysis; interferences; primary interference reactions; systematic errors; trace analysis.

Since the primary interference reactions may be a considerable source of systematic errors in fast particle activation analysis, their evaluation is of principal importance. These interferences can often be avoided or at least reduced to a negligible degree by the choice of the optimum projectile energy. In certain cases the interfering nuclear reactions cannot be avoided; then their extent must be evaluated quantitatively and corresponding corrections applied.

For the evaluation of the primary interference reactions by calculation, in addition to the appropriate projectile flux parameters, the cross section data must be known. A critical picture is provided of the present state of the cross section data required for this purpose with regard to their accuracy and completeness. Compilations from which the cross section data can be obtained are surveyed and discussed. A survey of systematics enabling the possibility to estimate unknown cross section data is given. The consequences of the uncertainty in nuclear data for the evaluation of primary reaction interferences are discussed and demonstrated by using practical examples. Handling of nuclear interferences in activation with 14 MeV neutrons, with fast neutrons of intermediate energy and with charged particles is considered.

In most cases, the cross section data needed for these calculations are, at present, already available. Generally, the accuracy suffices to make calculations for assessing the significance of the interferences and to choose the optimum projectile energy. The application of calculations to obtain the actual correction factors is possible only in cases where the cross section data have been critically evaluated and their accuracy is well known.

Activation analysis with charged particles of intermediate energy: Performances and applications, J. N. Barrandon and J. L. Debrun, *SP422*, pp. 1215-1232 (Aug. 1976).

Key words: activation analysis; charged particle; cyclotron; method evaluation; multielemental analysis.

The subject of this communication is activation analysis with intermediate energy protons (10 to 15 MeV) and $_2{}^3$He(10 to 20 MeV) with an emphasis on nondestructive multielemental analysis, but results obtained for single element determination after radiochemical separations are also reported.

Precision, accuracy, selectivity and sensitivity of the methods are discussed, as well as the possibilities of application in various areas including mainly metallurgy, geology, solid state physics and archeology.

In the case of nondestructive analysis with 10 MeV protons, we will present experimental activation yields for over 130 radioisotopes corresponding to more than 50 elements. Calculated sensitivities for the determination of these elements will be compared with experimental sensitivities obtained in actual analysis of various matrixes like: Ag, Al, Au, Co, Ir, Nb, Rh, Ta, rocks and graphite.

For destructive analysis with higher energy protons and $_2{}^3$He, our experimental results will be compared with results obtained on identical samples by other analytical methods like colorimetry, atomic absorption and mass spectrometry.

Organomercury and total mercury content of environmental matrices as determined by neutron activation analysis, E. Orvini and M. Gallorini, *SP422*, pp. 1233-1240 (Aug. 1976).

Key words: environmental matrices; extraction yields; mercury; neutron activation analysis; organomercury; solvent extraction.

Neutron activation analysis and the gas-chromatographic techniques are used in the determination of organomercury compounds and of total mercury in environmental matrices. In this work the benzene-cysteine separation procedure of Westôô was coupled to neutron activation analysis. In this way both the total mercury content and the organomercury fraction can be evaluated in one sample and during one radiochemical separation process. The activity of ^{197}Hg from the inorganic mercury content of the samples has been evaluated with a well-known combustion separation technique, carried out on the residual sample after benzene extraction. The activity of ^{197}Hg from organomercury compounds of the samples has been evaluated after extraction and purification with cysteine acetate from benzene fraction. The total mercury content was checked on an untreated portion of the same sample. Szilard-Chalmers reaction on the chemical bond between mercury and the organic radical seems to have a very low yield, down to 3 to 4 percent.

Determination of elements in standard material (Bovine Liver SRM 1577), I. Y. Donev and L. M. Marichkova, *SP422*, pp. 1293-1304 (Aug. 1976).

Key words: errors of analysis; homogenization; neutron activation analysis; sample preparation; standard materials; trace element analysis.

Investigations for quantitative determination of the elements: bromine, chromium, copper, iron, calcium, sodium, manganese and zinc in standard material Bovine Liver SRM 1577 have been carried out. Nondestructive neutron activation analysis was utilized. Gamma spectrometry was carried out with a 10 cm^3 Ge(Li) detector connected to a 4000 channel pulse height analyzer. In addition, some methodological procedures concerning the preparation of the standards are communicated, especially on the manipulation and origin of individual or systematic errors. Quantitative evaluations of these errors are given. Analytical results of trace element determinations, before and after cleaning, of Bulgarian polyethylene film, used as packaging material, are given.

A short description is also given of the procedure for rapid homogenization and drying of biological material at liquid nitrogen temperature for about 6 hours, where the water removed is about 85 percent. This enrichment is sufficient for investigations with the neutron activation analysis method. It is also important that the drying is carried out at 30 °C, so the danger for losses of different elements such as arsenic, selenium, silver, *etc.*, is reduced.

Evaluation of error in the instrumental activation analysis of rocks, R. J. Rosenberg, *SP422*, pp. 1241-1256 (Aug. 1976).

Key words: comparative analyses; error evaluation; geological materials; instrumental-neutron activation analysis.

In this paper, the overall error in instrumental activation analysis of rocks with a TRIGA Mark II reactor and the magnitude of its components, are evaluated. The analysis of lanthanides in the USGS standard rocks G-1 and W-1 is used as an example. In view of these results the possibility to decrease the error is discussed.

The average precision of the individual results obtained in this work is 11.6 percent and the average deviation of the mean is 4.6 percent. According to a comparison of values found in the literature the average error of results obtained in different laboratories is 11.8 percent and the average deviation of the results obtained in this work from the average of all results is 7.3 percent evenly distributed on both sides of zero.

The possible components of the error have been investigated partly experimentally and partly theoretically and the following was found to give noticeable contributions when 200 mg samples were used: The flux gradient causes an average error of 5.2 percent and thermalization in aquatic standards causes a negative error of 2.2 percent. Differences in counting geometry in measurements with the sample on the detector cause an error of 2.5 percent and differences in gamma-ray absorption cause an error that varies between 2.5 percent and below 1 percent. This error is negative when aquatic standards are used. Counting statistics causes an error that varies between 1 percent and 38 percent. The mean errors calculated from these data give a total error that varies between 9.0 and 42 percent with an average of 10.8 percent. A comparison between 10.8 percent and the average precision 12.8 percent of all results obtained in this work indicates that all errors of any importance are considered here. The mean error without counting statistics is 8.9 percent.

By rotating the samples during irradiation, counting with a few cm distance between sample and detector and by using rock-standards the total error can be decreased to the level of counting statistics. The same results can be obtained by decreasing the dimensions of the samples.

Neutron activation analysis for some nonstoichiometric constituents in a large number of natural and synthetic beryl samples, S. M. Ristic, *SP422*, pp. 1257-1274 (Aug. 1976).

Key words: cesium and scandium content; natural and synthetic beryls; neutron activation analysis.

About 100 natural beryls from very different locations were analyzed. An appreciable content of all five alkali metals was present, so that determination with a good precision was an important crystalochemical as well as geochemical problem. The trace amounts of Cr, As, Sc, Mn, Eu, and Dy in some natural samples, as well as Co, Ni, Fe, Mo, Sc, Cs and Na were measured in a gamma-spectrometric arrangement with a 500-channel pulse height analyzer, without chemical treatment (*i.e.*, in a nondestructive NAA procedure). The results obtained were partly controlled and compared by emission spectrography, flame spectrometry, and atomic absorption spectrometry, in order to determine the general reliability, as well as precision and accuracy in various analytical procedures and different samples.

Control of sample configuration as an aid to accuracy in instrumental neutron activation analysis, R. E. Heft, *SP422*, pp. 1275-1281 (Aug. 1976).

Key words: gamma counting efficiency; germanium detectors; instrumental neutron activation analysis; particulate sample geometry; trace elements in polyethylene powder.

Errors associated with the basic calculation common to all instrumental neutron activation analyses are discussed. The sample thickness of particulate or powdered samples contained in vials or cups is likely to be nonuniform and difficult to measure. To improve the accuracy of the counting efficiency determination, a procedure was developed for potting the samples in polyethylene to form cylindrical disks of polyethylene completely containing the sample material, uniformly distributed throughout the volume of the disk. Typically, 100 milligrams of sample is intimately mixed with 1 gram of polyethylene powder by gentle grinding in an agate mortar. The mixture is placed in a 2.54 cm diameter polycarbonate cylindrical cup and heated to 150 °C in a vacuum oven with a 3.81 cm long polycarbonate cylindrical rod of just under 2.54 cm diameter, in place, on top of the sample. At 150 °C the polyethylene melts and forms a highly viscous fluid which upon cooling forms a disk of fixed diameter with parallel faces and whose thickness is measurable to 0.05 millimeter. Blank corrections for the polyethylene are found to be small, and the disks serve as secure containers for the particulates during and after irradiation; and as counting samples of precise configuration for which counting efficiency can be accurately determined.

Observations on the quantitative electron probe microanalysis of particles, C. E. Fiori, K. F. J. Heinrich, R. L. Myklebust, and M. M. Darr, *SP422*, pp. 1283-1291 (Aug. 1976).

Key words: continuous radiation; electron probe microanalyzer; glass standard; lithium drifted silicon detector; Monte Carlo; particle analysis.

Elemental analysis of high accuracy with the electron probe microanalyzer is possible for flat specimens which are thicker than the depth of penetration of the electron beam. Existing data reduction procedures convert x-ray intensities to mass fractions of elements with typical accuracies of 1 to 2 percent (relative). These procedures will not work for specimens which are irregularly shaped and smaller than the range of the electron beam, such as dust particles. A Monte Carlo method is being developed to predict the expected x-ray intensity from particles of various shapes, sizes and compositions. We are also developing a method to measure the mass of a particle through the emitted continuous radiation. The expected end result of this work is an algorithm for quantitative microprobe analysis of particles. Experimental parts of this work include the manufacture and analysis of glass fibers and spheres of various diameters and widely varying composition.

SP423. **MFPG—Mechanical failure: Definition of the problem.** Proceedings of the 20th Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Washington, DC, May 8-10, 1974, T. R. Shives and W. A. Willard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 423*, 228 pages (Apr. 1976) SD Catalog No. C13.10:423.

Key words: brittle fracture; economics of failure prevention; fatigue failure; mechanical failure; mechanical reliability; stress corrosion cracking.

These Proceedings consist of 20 submitted papers and discussions from the 20th Meeting of the Mechanical Failures Prevention Group held at the National Bureau of Standards, May 8-10, 1974. The central theme of the proceedings is the definition of the problem of mechanical failure, with emphasis on modes of failure, consequences of mechanical failure, and implications of mechanical failure. *These proceedings include the following papers (indented):*

What we can learn from the examination of service failures, J. A. Bennett, *SP423*, pp. 3-11 (Apr. 1976).

Key words: crack propagation; failure analysis; failure prevention; fracture; fractography; mechanical failure.

The study of metal components that have fractured in service provides information that can be of major importance

in preventing future failures. The metallurgical and fractographic techniques used in such studies are described so as to permit an evaluation of the reliability of the results. Examples are given of some case histories in which the fracture studies were highly effective, and of others in which the information was ignored and further failures occurred.

Failure by fatigue, A. J. McEvily, *SP423,* pp. 13-24 (Apr. 1976).

Key words: crack initiation; crack propagation; fatigue crack growth; fatigue failure; metal fatigue.

The lifetime of manufactured items under intended service conditions is often limited by the processes of corrosion, wear and fatigue. Since such processes represent economic loss and perhaps a safety hazard to the consumer, much effort has gone into the understanding of these phenomena as well as into improved design procedures to guard against their occurrence. In the field of fatigue in particular a considerable advance in recent years has been made in the quantitative treatment of the fatigue process, especially with respect to the matter of fatigue crack growth. Improved understanding of the fatigue crack growth process is timely as in certain circumstances, as for example in the case of welded structures, it is not the initiation of cracks but rather the growth of cracks from preexisting defects which is the critical aspect in determining service lifetime. Other advances have been made in improving the resistance of materials to fatigue either through the control of chemistry or by control of processing variables. Such procedures are generally more important in affecting the crack initiation rather than the crack propagation stages. In this presentation a review of the current status of fatigue will be given from the mechanistic as well as the design viewpoints. Areas in need of further understanding such as corrosion fatigue, creep-fatigue, and fatigue under variable amplitude loading will also be considered.

Failure by stress corrosion cracking—Current approaches toward failure prediction, J. Kruger, *SP423,* pp. 27-40 (Apr. 1976).

Key words: corrosion; failure prediction; film rupture-metal dissolution; hydrogen embrittlement; stress corrosion cracking; stress-sorption.

Stress corrosion cracking (SCC) produces failures in a material when it is subjected to the combined effects of mechanical stress and reaction with an environment. All proposed mechanisms of SCC seek to explain how the combination of a given level of stress, a particular material, and a given environment can lead to the initiation and propagation of cracks. The three major categories of mechanisms that are generally proposed are (1) active path dissolution, (2) stress-sorption, and (3) embrittlement.

In recent years attempts to determine the mechanisms have been enhanced by new concepts and techniques that flow from the three major scientific disciplines that underlie the complex problem of SCC—chemistry, metallurgy, and mechanics. From chemistry have come two main currents: (a) increased awareness of the importance of characterizing the altered environment inside a growing crack, and (b) a recognition of the importance of the regrowth rate of a protective film on a bare surface exposed when that film is broken by stress. The main emphasis in the metallurgy of SCC has been on the crucial role played by structure in general, and particularly at the tip of a crack. Aiding this objective has been the use of the high voltage electron microscope which can directly look at the interaction of the environment with structural defects, e.g., dislocations. Finally, the major thrust in the mechanics of SCC has been the application of the concepts and techniques of fracture mechanics.

The impact of these new concepts and measurement techniques on predicting and preventing SCC failure will be discussed.

Elastohydrodynamics in concentrated contacts, H. S. Cheng, *SP423,* pp. 41-54 (Apr. 1976).

Key words: contact lubrication; elastohydrodynamic contacts; fatigue; lubricant film thickness; scuffing; wear.

Typical geometrical features of elastohydrodynamic (EHD) contacts and major operating, lubricant, and material parameters governing lubrication in these contacts are described. Operating regimes for various machine components, such as gears, rolling element bearings, cams, and compliant bearings, are identified. A state-of-the-art survey is given to the predictability of major EHD characteristics based on existing analytical and experimental EHD research. The significance of film thickness, pressure fluctuations, friction, and temperature in affecting failures of concentrated contacts by fatigue, scuffing, and wear is discussed. Finally, suggestions are made to incorporate the EHD effects in predicting fatigue life, scuffing load, and wear rate.

Failure in gears and related machine components, R. A. Wilde, *SP423,* pp. 55-66 (Apr. 1976).

Key words: abrasive wear; adhesive wear; gear failure; machine component failure; mechanical failure; surface pitting.

Tooth breakage and abrasive wear are gear failure mechanisms that are well understood. Adhesive wear (scuffing and scouring) and surface pitting are more complex failure mechanisms.

When sliding is introduced into the rolling condition the rubbing between partially lubricated surfaces introduce high surface tensile stresses which result in adhesive wear and surface pitting. Neither of these failures will occur if a continuous oil film separates the metal surfaces.

Because these failures are the result of the interaction of many variables, a systems approach is required to understand the nature of the failure. The following variables have a direct effect on the thickness of the oil film and therefore on the amount of metal to metal contact: Surface roughness, direction of scratches relative to the sliding direction, oil viscosity, conjunction temperature, rolling speed, relative sliding speed, oil composition and load (Hertz stress). These variables will have significantly different effects when sliding is introduced to the rolling condition as occurs in gear applications.

Bearing damage analysis, R. L. Widner and W. E. Littmann, *SP423,* pp. 67-84 (Apr. 1976).

Key words: bearing failure; bearing loading; bearing lubrication; bearing misalignment; bearing temperature; mechanical failure.

Failure analysis of machine components is described with the major emphasis on tapered roller bearings and their interactions with other components of a system. Included in the discussion are the effects of loading, deflections, misalignment, lubrication, temperature, debris, water and electrical current on the type of damage and life of tapered roller bearings.

Anti-friction bearing design, inspection and recycling, K. M. Glaesner, *SP423,* pp. 87-91 (Apr. 1976).

Key words: aircraft engine bearings; antifriction bearings; bearing failure; bearing failure modes; bearing inspection; bearing reclamation; bearing recycling.

The paper will describe the ramification of failures of antifriction bearings related to aircraft applications, including engine bearings. The paper will endeavor to describe the problems of antifriction bearings in four categories:

I. Design of application. Here, the paper will describe the inherent design failures as noted in applications. The paper will also include parameters of bearing design which will best provide operational success and life expectancy.

II. Failure modes in bearing applications will be described and an outline of the most popular types of failure as detected in bearings, will be discussed.

III. A recovery process for the reclamation of bearings will be outlined and again limits for the acceptability of defects on bearings will be presented.

IV. New inspection techniques now under study will be outlined and the method of inspection will detail failure prevention once the bearing is mounted in the application.

Holographic NDI of P-3 wing plank splices, A. J. Koury, M. J. Devine, J. F. Erthal, and P. D. Bhuta, *SP423,* pp. 93-103 (Apr. 1976).

Key words: aircraft component failure; continuous wave holograms; crack detection; holographic techniques; pulsed laser holograms; stress corrosion cracking; ultrasonic inspection.

Continuous wave and pulsed laser holographic techniques were applied to inspect stress corrosion cracking in P-3 wing plank splices. Holographic results were compared with those of currently used ultrasonic inspection techniques. Holographic techniques successfully detected all the stress corrosion cracking areas that were identified by the ultrasonic inspection technique and, in addition, several other crack areas were located whose presence was later verified by dye penetrant inspection after careful disassembly of the panel joints. It was also shown that the holographic technique can locate areas of stress corrosion cracking without removal of paint and sealant materials. The currently used ultrasonic technique requires a paint and sealant stripping operation prior to inspection. Considerable savings in cost will be realized when inspection using holographic techniques is implemented. The holographic technique was demonstrated to Navy personnel at the Naval Air Rework Facility, Alameda, California, in an air rework environment. The concept of "structural signature" to verify structural integrity of complex aircraft structures is briefly described.

Economic considerations in failure prevention, H. E. Morgan, *SP423,* pp. 107-116 (Apr. 1976).

Key words: economic cost of failure prevention; frequency of failure; government action; life-cycle costing; marginal analysis; quality control; safety standards.

Economic considerations normally determine if product failure prevention is justified by a producing firm. Some failures are not worth preventing, even if prevention is technically feasible. Since the risk of failure is inherent in all products, the expected benefits of failure prevention should be compared with expected costs, both discounted to present value in a life-cycle context and compared with alternatives.

Producers and users of a product may evaluate the risk of failure and its economic cost differently. This may lead to inefficient and inequitable production decisions affecting the public interest. Consequently, externalities (third-party effects) may require that regulatory or other agencies of Government intervene to protect the public and to insure socially efficient and equitable allocation of resources to failure prevention.

Failures represent a gap between expectations and performance. Both involve measurement and standards technology which the NBS can provide. However, economic analysis should be used to determine the conditions under which failure prevention is desirable. Examples of economically desirable conditions for failure prevention are provided.

Economic impact of tribology, H. P. Jost, *SP423,* pp. 117-139 (Apr. 1976).

Key words: economic savings of failure prevention; friction; lubrication; mechanical failure; tribology; wear.

The emergence of tribology as a subject in its own right arose out of industrial need. In the early 1960's there was a large increase in reported failures of plant and machinery due to wear and associated causes. At the same time, technology was increasing the capital intensity of plant and the use of more continuous processes; thus breakdowns of such plant and machinery were becoming more costly.

In 1966 a U.K. Government investigation came to the conclusion that by application of tribological principles, very large savings were obtainable, in most cases without appreciable capital investment.

Tribology was defined as "the science and technology of interacting surfaces in relative motion and of subjects and practices related thereto." In other words, it deals with all aspects of rubbing, sliding and rolling surfaces and included the subjects of wear, friction and lubrication. Application of tribological principles would lead not only to greater operational reliability, efficiency and productivity, but also to conservation of materials and energy.

To gain the advantages outlined in the above Report, estimated at the time to be in the region of £515 million per annum (p.a.) ($1285 million approximately), the British Government set up the Committee on Tribology, to implement the recommendations in the education, research and industrial fields.

Actual savings already resulting to British industry are conservatively estimated to be in excess of £100 million p.a. ($230 million), and potential savings (allowing for inflation since the 1966 estimate) to over £1,000 million p.a. ($2,300 million).

In less than seven years, the new concept of tribology has been accepted by the majority of the industrial countries as part of their scientific and technological background in the field of obtaining greater plant efficiency, better performance, fewer breakdowns and significant savings in other directions.

Nuclear power plant safety, P. A. Morris, *SP423,* pp. 143-151 (Apr. 1976).

Key words: failure prevention; mechanical failure; mechanical malfunction; quality assurance; reactor systems and components; safety standards.

Protection against the potential radiological consequences of malfunction or mechanical failure of reactor systems and components in nuclear power plants is achieved by a combination of procedural and technical constraints. For routine operation, plants are to be designed and operated so that radioactive effluents are maintained as low as practicable. To assure that the probability of serious accidents is ac-

ceptably low requires conservative design, construction and operation using redundant and diverse systems and components and a rigorous program for quality assurance at all times.

Mechanical failures and public expectations of safe transportation, H. H. Wakeland, *SP423*, pp. 153-163 (Apr. 1976).

Key words: effects of mechanical failure on environment; failure prevention; government action; mechanical failure; safety standards; transportation safety.

Although, in the interaction between society and technology, it is desired to minimize the incidence of mechanical failure under all conditions, the practical ability to circumscribe and control failures in transportation (for example) varies widely. Depending upon identifiable variables in circumstances, society may effectively require a range of performance between complete freedom from failure and general acceptance of repeated failures of a life-threatening nature. An attempt is made to classify the variables of circumstance which seem to govern public expectation and to create a structure in which the degree of freedom from mechanical failure which will be tolerated by the public can be reviewed. The possibility of using this structure for estimating public reaction to failures is discussed.

Public safety and construction surety, J. Feld, *SP423*, pp. 165-170 (Apr. 1976).

Key words: construction safety; construction surety; degradation of safety with age and use; maintenance of safety; public safety; safety responsibility.

Structures are conceived, designed and constructed for use by man and located in proximity to other structures and open spaces occupied by man. How safe are these structures when first occupied, and what degree of safety can be expected of them with age?

Who is responsible for the original condition of safety of the structures, and for the degradation of safety with age and use?

Who is responsible for the maintenance of sufficient safety to permit continued use and occupancy?

In addition to the broad aspects of the problem, the paper will describe avoidable use of incompatible materials that caused local distress or failure of the structure.

Public safety and construction surety depend on proper control of each factor involved in the design, construction, maintenance, and use of a structure. Any deviation on the part of any one factor makes the structure vulnerable to damage or even collapse. Absolute safety is not obtainable. The historical record of structure behaviour indicates the high reliability of present techniques and procedures.

Responsibility for defects and for the small percent of structures that do not perform properly is a deterrent to proper control, but considerable pressure is needed to further reduce the number of failures to insignificant numbers. It is the duty of the professions involved to provide that pressure, since legal and political action has not been successful, and to control the proper performance of the work in every factor and so provide public safety and surety in the construction industry.

The people considerations of automotive service, F. J. Uhlig, *SP423*, pp. 171-178 (Apr. 1976).

Key words: automotive repair; automotive repair effectiveness; automotive service; customer-mechanic relationship; human factor considerations; universal symbol diagram approach.

The presentation will cover some of the human factor considerations in servicing automobiles at GM dealerships. Emphasis will be placed on the communication channel between customer and mechanic and possible attendant breakdown that can limit the effectiveness of repairs. Specifically, the repair challenge will be described relative to: (1) Vehicle relation and consumer expectations; (2) The customer item-service writer interface; (3) Technical service information for internal service shop communications.

In addition, the presentation will cover some recent developments of GM service research which address themselves to the above problems for example: (1) Service writer check sheet—a vehicle simulator oriented approach to customer order write up; (2) "STAR"—A computerized reading comprehension method for use in improving the readability of service manuals used by mechanics; (3) "USDA"—Universal Symbol Diagnosis Approach—that uses graphic symbols in a logic tree format to aid in vehicle system problem diagnosis; (4) Shop operation management system.

Mechanical failures: Implications for science; J. P. Hirth, *SP423*, pp. 181-191 (Apr. 1976).

Key words: continuum cracks; continuum mechanics; failure mechanisms; mechanical failure; microstructural effects on mechanical failure.

The early scientific advances by Griffith for continuum cracks and by Orowan, Taylor, Hall and Petch, and Hirsch and coworkers for effects of microstructure have contributed to our current understanding of mechanical failure. However, this understanding remains incomplete. Here, a brief historical account and survey of the present status of various fundamental aspects of the failure problem are presented. Specific unsolved problems and areas for needed research are suggested.

Implications for action for engineering, H. W. Paxton, *SP423*, pp. 193-197 (Apr. 1976).

Key words: environmental extremes; fail-safe operation; high strength materials; mechanical failure; potential service conditions; proliferation of specifications.

The demands on materials for fail-safe operation have increased enormously since the days of "Galloping Gertie" and Liberty Ships. The necessity to use higher strengths has increased demands on selection, design, acceptance testing, nondestructive evaluation of structures, and manufacturing methods. Extremes of temperatures, thicker sections, and environmental effects have all accentuated the tendency for mechanical failure. This paper will discuss the current status of selected problems, and by assessing our fundamental understanding of certain important engineering parameters, will examine prospects for improved materials and techniques.

Mechanical reliability—Implications for engineering, manufacturing and design, W. D. Compton, *SP423*, pp. 199-208 (Apr. 1976).

Key words: design engineering; material deterioration; mechanical failure; mechanical integrity; mechanical reliability; performance envelope; predicting product reliability.

The automobile is a complex assembly of some 15 000 different components in a network of functional subsystems and systems. The definition of the problem of mechanical performance is complicated by the absence of a fixed vehicle performance envelope. Control over use of the vehicle

is in the hands of the individual driver. This is substantially different from military and aerospace hardware for which there are specified performance envelopes, and from many consumer products in which the performance follows a fixed pattern, almost independent of consumer preference. This situation imposes special implications for engineering and design, and for testing.

Improved methodologies for predicting component durability and lifetime under real-life conditions, when combined with information on material and structure properties derived under realistic test conditions, can be of great value in developing designs with improved mechanical properties. Likewise, the high volume production rates associated with automotive components involve consideration of material processing and manufacturing factors if the proper levels of mechanical performance are to be achieved.

Implications for action—Industry, J. E. Ryan, *SP423,* pp. 209-212 (Apr. 1976).

Key words: consumer products; marketing; mechanical failure; product performance; product reliability; product testing.

This paper will review product trends for industrial and consumer durables; the foreseeable environment of production and use of these products and systems; and the implications for preventive action in this industrial area based upon the growing body of knowledge of mechanical failure mechanisms and the increasing concern for economic and social consequences of mechanical failures.

The implications of mechanical failures for consumer product safety—Vice versa, L. M. Kushner, *SP423,* pp. 215-219 (Apr. 1976).

Key words: consumer product safety; failure prevention; government action; government responsibility; mechanical failure; safety standards.

In years past, manufacturing a safe product (rather than one that is simply marketable) for the consumer was regarded as a nice, but not necessarily imperative, thing for a manufacturer to do. Recent legislation, however, mandates consumer product safety, thereby putting additional responsibilities on product designers and engineers and the research scientists who support them. Experience in operating a regulatory product safety program discloses that materials failures, many of which are mechanical in nature, are an important factor in consumer product safety. A discussion will be presented of the implications of the Consumer Product Safety Act for materials engineers. Some specific examples of mechanical failures in consumer products that have created serious safety problems will be given.

Mechanical failure—A material matter, R. W. Roberts, *SP423,* pp. 221-225 (Apr. 1976).

Key words: conservation of material resources; failure prevention; government action; mechanical failure; mechanical reliability; safety standards.

The Federal Government has long been concerned with minimizing mechanical failures. This concern has come about for two reasons. First, the Federal Government purchases and operates a great deal of equipment, much of it, as in the space program and in the DOD, equipment of extreme technological sophistication. The Government, in purchasing, using, and maintaining this equipment, has often led the way in devising new approaches to mechanical reliability. The second reason involves areas of broad public concern, such as safety. Here, Congress has granted Government agencies the authority to set mandatory standards that are designed to prevent mechanical failures in the private sector. It is clear that in the future both these activities will be continued.

In addition, several current national trends call for enhanced concern with mechanical reliability. These trends are related to the conservation of natural resources, the continuing need for new methods of improving product quality and maintainability in the face of rising labor costs, and the growth of new technologies, such as nuclear energy, requiring a new plateau of operating reliability.

These trends are analyzed in terms of future government policy and future modes of interaction between the government and the private sector.

SP424. **A contribution to computer typesetting techniques: Tables of coordinates for Hershey's repertory of occidental type fonts and graphic symbols,** N. M. Wolcott and J. Hilsenrath, *Nat. Bur. Stand. (U.S.), Spec. Publ. 424,* 173 pages (Apr. 1976) SD Catalog No. C13.10:424.

Key words: alphabets; COM; computerized typesetting; digital plotting; graphics; Hershey character set; plotting; type fonts; typesetting; vectorized characters.

These tables present coordinates from which it is possible to generate 1377 different alphabetic and graphic characters on either COM devices or on digital plotters. The tables, originally developed by Dr. A. V. Hershey of the Naval Weapons Laboratory, are augmented here by corresponding figures which show for each character the location of the tabulated points and the manner in which they are connected. The tables can be used with existing typographic systems to compose pages for scientific and mathematical publications of graphic arts quality either on COM devices or flat-bed plotters. Numerous applications are discussed and illustrated. The tables are also available on a magnetic tape in either BCD or ASCII format from the National Technical Information Service.

SP426. **Bibliography of low energy electron and photon cross section data (through December 1974),** L. J. Kieffer, *Nat. Bur. Stand. (U.S.), Spec. Publ. 426,* 219 pages (Mar. 1976) SD Catalog No. C13.10:426.

Key words: atom; collision cross section; detachment; dissociation; elastic scattering; electron; excitation; fluorescence; ion; ionization; molecule; photon; positron.

A bibliography of original reports of measurements or calculations of electron, positron and photon cross sections and their ions is presented. A detailed index to the bibliography allows retrieval of cross section data for specific processes and atomic or molecular species. A comprehensive author index is included. The bibliography covers the period 1921 through calendar year 1974 but some references late in 1974 may not have been found and included. No references were found prior to 1921.

SP428. Parts 1, 2, and 3. **Bibliography of infrared spectroscopy through 1960,** C. N. R. Rao, S. K. Dikshit, S. A. Kudchadker, D. S. Gupta, V. A. Narayan, and J. J. Comeford, *Nat. Bur. Stand. (U.S.), Spec. Publ. 428/1-3,* 2399 pages (Jan. 1976) SD Catalog No. C13.10:428/1-3.

Key words: bibliography; data; infrared; inorganic; minerals; ores; organic; polymers; spectroscopy.

This bibliography is based on a systematic search of the literature on infrared spectroscopy up to the end of 1960. It covers, directly or through abstract journals, 121 periodicals. As a general rule, any paper of interest in the field of infrared spectroscopy is included. Substance coverage is provided in four sec-

tions: organic compounds, inorganic compounds, polymeric compounds, and minerals and ores. Information provided includes: empirical formula, compound name, range of wavelengths reported, state of material, type of data presented in paper, and literature reference. Issued in three parts.

SP431. **Fourth international congress for stereology.** Proceedings of the Fourth International Congress for Stereology held at the National Bureau of Standards, Gaithersburg, MD, Sept. 4-9, 1975, E. E. Underwood, R. de Wit, and G. A. Moore, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 431,* 547 pages (Jan. 1976) SD Catalog No. C13.10:431.

Key words: stereology; stereometry; stereoscopy; stochastic models; structures; three-dimensional reconstruction.

These proceedings contain most of the papers presented at the technical sessions and workshops of the Fourth International Congress for Stereology, held at the National Bureau of Standards, Gaithersburg, Maryland, from 4-9 September 1975. Of the 113 papers recorded here, 10 are invited lectures, 66 are submitted papers, and 37 come from the six workshops. Three of these workshops containing 17 papers were integrated into the technical sections for these proceedings. Topics covered in the Technical Sections are Principles and Mathematical Developments, Pattern Recognition, Instrumentation, Three-dimensional Reconstruction, and Stereological Applications in Materials and Biology. Additional topics covered in the Workshops are Mathematical Foundations of Stereology, Particle Science, and Size Distributions. *These proceedings include the following papers (indented):*

On estimating aggregate and overall characteristics from thick sections by transmission microscopy, R. E. Miles, *SP431,* pp. 3-12 (Jan. 1976).

Computational methods in stereology, R. S. Anderssen and A. J. Jakeman, *SP431,* pp. 13-18 (Jan. 1976).

Estimation of linear functionals by maximum likelihood, W. L. Nicholson, *SP431,* pp. 19-24 (Jan. 1976).

The geometry and stereology of "Cubo-Spherical" particles, R. Warren, *SP431,* pp. 25-28 (Jan. 1976).

Quantitative microscopy of lineal features in three dimensions, R. T. DeHoff and S. M. Gehl, *SP431,* pp. 29-40 (Jan. 1976).

Connectivity of "Dispersed" particles: A probabilistic computation, G. A. Moore, *SP431,* pp. 41-44 (Jan. 1976).

Analytic results for the connectivity of dispersed particles, R. de Wit, *SP431,* pp. 45-48 (Jan. 1976).

Topological analysis of dendritic trees, M. Berry, *SP431,* pp. 49-54 (Jan. 1976).

Theoretical and experimental studies of the stereological properties of porosity, specific surface, and connectivity, R. B. Martin, *SP431,* pp. 55-58 (Jan. 1976).

Assessment of sampling errors in stereological analysis, J. E. Hilliard, *SP431,* pp. 59-67 (Jan. 1976).

On optimal forms for stereological data, A. J. Jakeman and R. S. Anderssen, *SP431,* pp. 69-74 (Jan. 1976).

Multivariate data analysis to describe intra- and intergranular relations in thin sections, W. Good, *SP431,* pp. 75-78 (Jan. 1976).

Correction of stereological parameters from biased samples on nucleated particle phases, L. M. Cruz-Orive, *SP431,* pp. 79-82 (Jan. 1976).

Stochastic models in stereology: Strength and weaknesses, J. P. Serra, *SP431,* pp. 83-86 (Jan. 1976).

A stereological view of data analysis, G. A. Moore and G. T. Eden, *SP431,* pp. 87-90 (Jan. 1976).

Three-dimensional shape parameters from planar sections, E. E. Underwood, *SP431,* pp. 91-92 (Jan. 1976).

Interpretation of some of the basic features of field-ion image projections from a hemispherical to a planar surface using Moire patterns, P. D. Ownby, R. M. Doerr, and W. Bollmann, *SP431,* pp. 93-98 (Jan. 1976).

Network simulation of connectivity and aggregate size in two-phase mixtures, W. D. Leahy and J. H. Steele, Jr., *SP431,* pp. 99-105 (Jan. 1976).

What can pattern recognition do for stereology?, G. C. Cheng, *SP431,* pp. 107-112 (Jan. 1976).

Theory and applications of imagery pattern recognition, C. H. Chen, *SP431,* pp. 113-116 (Jan. 1976).

A new, fast and storage-saving image analysis procedure for investigating individuals by a digital computer, M. Rink, *SP431,* pp. 117-120 (Jan. 1976).

System for computer input and processing of two-dimensional pictures, I. Krekule and M. Indra, *SP431,* pp. 121-122 (Jan. 1976).

Pattern recognition on the quantimet 720 image analyzing computer, K. E. Lawson, *SP431,* pp. 123-126 (Jan. 1976).

Recognition and classification of structure by means of stereological methods in neurobiology, G. Bernroider, *SP431,* pp. 127-132 (Jan. 1976).

Projectors in pattern recognition categories, M. Pavel, *SP431,* pp. 133-139 (Jan. 1976).

Automatic image analyzing instruments today, H. P. Hougardy, *SP431,* pp. 141-148 (Jan. 1976).

Texture analysis of stereological specimens, W. Hunn, *SP431,* pp. 149-154 (Jan. 1976).

A computerized image process for isolating individuals in an originally netted pattern, M. Rink, *SP431,* pp. 155-158 (Jan. 1976).

An image analysis system based on feature descriptors, R. R. A. Morton, *SP431,* pp. 159-162 (Jan. 1976).

Implications of recent advances in image analysis for stereological theory, H. Schmeisser, *SP431,* pp. 163-166 (Jan. 1976).

Experiences with optomanual automated evaluation-systems in biological research, especially in neuromorphology, H. Haug, *SP431,* pp. 167-172 (Jan. 1976).

A user-oriented automatic scanning optical microscope, J. E. Hilliard, *SP431,* pp. 173-176 (Jan. 1976).

The determination of particle shape and size distributions using automatic image analysis techniques, J. Slater and B. Ralph, *SP431,* pp. 177-180 (Jan. 1976).

Some shape functions for use in automatic image analysers for the classification of particulate materials, A. C. Terrell and R. J. Willes, *SP431,* pp. 181-184 (Jan. 1976).

Determination of particle size and shape distribution by automatic feature analysis, J. R. Schopper, *SP431,* pp. 185-188 (Jan. 1976).

Stereology and the automatic linear analysis of mineralogical materials, M. P. Jones and G. Barbery, *SP431,* pp. 189-192 (Jan. 1976).

A new opto-manual semi-automatic evaluation system, H. P. Rohr, *SP431,* pp. 193-195 (Jan. 1976).

Automated measurements for determination of the statistical nature of the distribution of inclusions in steel, G. A. Moore, *SP431,* pp. 197-198 (Jan. 1976).

Reconstruction from projections: A survey of applications, R. Gordon, *SP431,* pp. 201-202 (Jan. 1976).

Morphometric analysis of neurons in different depths of the cat's brain cortex after hypoxia, O. Hunziker, U. Schulz, C. Walliser, and J. Serra, *SP431,* pp. 203-206 (Jan. 1976).

Three-dimensional reconstruction from serial high voltage electron micrographs, L. D. Peachey, C. H. Damsky, and A. Veen, *SP431,* pp. 207-210 (Jan. 1976).

Determining three-dimensional intracellular structure data from scanning proton microscopy luminescence data, D. G. Oldfield, *SP431,* pp. 211-214 (Jan. 1976).

Artifacts in three-dimensional reconstruction from medical radiographic data, E. L. Hall, G. C. Huth, R. A. Gans, and I. S. Reed, *SP431,* pp. 215-218 (Jan. 1976).

Artificial stereo: A generalized computer algorithm for combining multi-channel image data, W. G. Pichel, R. L. Brower, D. R. Brandman, and R. J. Moy, *SP431,* pp. 219-220 (Jan. 1976).

Stereoscopic photomacrography and stereoscopic projection, Y. Fujimoto and Y. Ohta, *SP431,* pp. 221-222 (Jan. 1976).

Holographic methods for in-depth viewing of microscopic subjects, R. J. Schaefer and J. A. Blodgett, *SP431,* pp. 223-224 (Jan. 1976).

Evaluation of a new technique for determining the volume of the human left ventricle from one-plane radiographic measurements, R. Moore, I. Beranek, S. Kim, and K. Amplatz, *SP431,* pp. 225-228 (Jan. 1976).

Movie: Prim-9. Viewing high dimensional point clouds, J. W. Tukey, *SP431,* p. 229 (Jan. 1976).

Applications of quantitative microscopy in metal science, F. N. Rhines, *SP431,* pp. 233-244 (Jan. 1976).

Applications of stereological techniques to the quantitative characterization of wood microstructure, J. H. Steele, Jr., G. Ifju, and J. A. Johnson, *SP431,* pp. 245-256 (Jan. 1976).

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Stereological analysis of neural organogenesis in the chick embryo, O. Mathieu and P. E. Messier, *SP431,* pp. 393-396 (Jan. 1976).

Application of stereological methods to the study of preimplantation embryogenesis in mice, R. L. Deter, *SP431,* pp. 397-400 (Jan. 1976).

The determination of size distribution on lymphoblasts in acute leukemia, E. Feinermann and G. A. Langlet, *SP431,* pp. 401-404 (Jan. 1976).

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The effects of optical resolution on the estimation of stereological parameters, H. J. Keller, H. P. Friedli, P. Gehr, M. Bachofen, and E. R. Weibel, *SP431,* pp. 409-410 (Jan. 1976).

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Introduction remarks, B. H. Kaye, *SP431,* pp. 467-468 (Jan. 1976).

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The application of stereology to particle technology, B. Scarlett and P. J. Lloyd, *SP431,* pp. 477-482 (Jan. 1976).

Techniques for particle measurement using image analysis, R. R. A. Morton, *SP431,* pp. 483-486 (Jan. 1976).

Microscopic characterization of fine powders, P. Ramakrishnan, *SP431,* pp. 487-490 (Jan. 1976).

Stereology of paint films, B. H. Kaye and I. Robb, *SP431,* pp. 491-492 (Jan. 1976).

Concluding remarks, B. H. Kaye, *SP431,* p. 493 (Jan. 1976).

Estimation of linear properties of spherical bodies in thin foils from their projections, F. Piefke, *SP431,* pp. 497-498 (Jan. 1976).

On size distribution methods, F. A. L. Dullien and K. S. Chang, *SP431,* pp. 499-502 (Jan. 1976).

Size distribution of retained austenite phase in a quenched stainless steel, A. V. Samudra and O. Johari, *SP431,* pp. 503-506 (Jan. 1976).

Analysis of a set of spherical cells relative to their volume, P. d'Athis, *SP431,* pp. 507-508 (Jan. 1976).

Appendix—Basic stereology, E. E. Underwood, *SP431,* pp. 509-512 (Jan. 1976).

SP432. **NBS time and frequency dissemination services,** S. L. Howe, Ed., (Supersedes NBS Special Publication 236, 1974 and previous editions), *Nat. Bur. Stand. (U.S.), Spec. Publ. 432,* 32 pages (Jan. 1976) SD Catalog No. C13.10:432.

Key words: broadcast of standard frequencies; frequency calibration; high frequency; low frequency; standard

frequencies; television color subcarrier; time calibration; time signals.

Detailed descriptions are given of the time and frequency dissemination services of the National Bureau of Standards. These services include the broadcasts from radio stations WWV, WWVH, WWVB, and WWVL, and new time and frequency calibration services using television. This publication shows the services available on January 1, 1976. It will be updated only when the services are revised or when new services are added. A list of other publications available about the Time and Frequency Division is also included.

SP433. **MFPG—Success by design: Progress through failure analysis.** Proceedings of the 21st Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, MD, Nov. 7-8, 1974, T. R. Shives and W. A. Willard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 433,* 229 pages (July 1976) SD Catalog No. C13.10:433.

Key words: design; engineering education; failure analysis; failure analysis case histories; failure prevention; reliability; safety.

These Proceedings consist of a group of twenty-two submitted papers and discussions from the 21st meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards in Gaithersburg, Maryland on November 7-8, 1974. The central theme of the Proceedings was improvement in design through failure analysis. Emphasis was on design philosophy, the use of failure analysis case studies as an educational tool, successful redesign through failure analysis, and design oversights. *These proceedings include the following papers (indented):*

Creative student engineering design, P. S. De Jong, *SP433,* pp. 3-5 (July 1976).

The designer's contribution in the development of new products, J. J. Lesko, *SP433,* pp. 7-14 (July 1976).

Successful redesign and launch performance of the ERTS/Nimbus adapter after an acceleration test failure, V. T. Sweet and W. B. Keegan, *SP433,* pp. 19-72 (July 1976).

Agricultural equipment for underdeveloped countries, C. W. Suggs, *SP433,* pp. 74-81 (July 1976).

Safety success through design, D. W. Logan, *SP433,* pp. 83-87 (July 1976).

Reliability, pollutants and aluminum raw material, V. D. Matney, *SP433,* pp. 89-101 (July 1976).

Rotor burst protection program, G. J. Mangano, *SP433,* pp. 103-119 (July 1976).

Airframe "crashworthiness" experiments, N. N. Shapter, *SP433,* pp. 122-128 (July 1976).

Redesign and assembly of anti-friction bearing housings for improved life, G. D. Xistris and D. C. Watson, *SP433,* pp. 131-142 (July 1976).

Case history of failures in a hammer mill, J. K. L. Bajaj, *SP433,* pp. 144-158 (July 1976).

Solution of an art restoration problem, E. Passaglia, *SP433,* pp. 159-161 (July 1976).

Elimination of failures of U-bolts in farm tractor dual wheels, B. P. Bardes, *SP433,* pp. 164-165 (July 1976).

Structural in-flight wing failures, M. L. Marx, *SP433,* pp. 166-177 (July 1976).

Use of cases in engineering education—Their special value, H. O. Fuchs, *SP433,* pp. 180-182 (July 1976).

What can be learned from cases, G. Kardos, *SP433,* pp. 183-187 (July 1976).

Student written design case studies, C. O. Smith, *SP433,* pp. 188-190 (July 1976).

Teacher feedback on the use of engineering case studies, B. J. Pelan, *SP433,* pp. 192-198 (July 1976).

Some thermal problems in the design of fluid film bearings, D. D. Fuller, *SP433,* pp. 205-211 (July 1976).

Never overlook notches, C. O. Smith, *SP433,* pp. 212-213 (July 1976).

Innovation or reliability, H. O. Fuchs, *SP433,* pp. 214-215 (July 1976).

The "model" designer, R. E. Maringer, *SP433,* pp. 216-217 (July 1976).

The misuse of tensile strength as a design parameter, T. J. Dolan, *SP433,* pp. 218-219 (July 1976).

Inspection consideration at the design stage, J. F. Erthal, *SP433,* p. 222 (July 1976).

SP434. **Hydrocarbons for fuel—75 years of materials research at NBS,** G. T. Armstrong, *Nat. Bur. Stand. (U.S.), Spec. Publ. 434,* 20 pages (May 1976) SD Catalog No. C13.10:434.

Key words: coal; energy; fuel; graphite; hydrocarbons; metering; methane; natural gas; petroleum; physical properties; standard reference materials.

In this historical review the NBS work on hydrocarbons is discussed in terms of the three major classes of natural hydrocarbonaceous fuels: natural gas, petroleum, and coal. The work done on the measurement of properties of the pure components has included measurement of the values of the properties themselves and development of practical and accurate measurement procedures and instruments. In addition, combustion energies, densities, viscosities, vapor pressures, refractive indices, elemental compositions and other parameters have been determined for complex fuel mixtures and correlated to find methods of estimating properties. Extensive standard reference data tables have been compiled and a number of standard reference materials have been developed.

SP435. **Laser induced damage in optical materials: 1975.** Proceedings of a Symposium sponsored by: National Bureau of Standards, American Society for Testing and Materials, Office of Naval Research, Energy Research and Development Administration, NBS Boulder, CO, July 29-31, 1975, A. J. Glass and A. H. Guenther, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 435,* 437 pages (Apr. 1976) SD Catalog No. C13.10:435.

Key words: avalanche ionization; IR windows and mirrors; laser damage; laser materials; multiphoton processes; self-focusing; thin films.

The Seventh ERDA-ASTM-ONR-NBS Symposium on Laser Induced Damage in Optical Materials was held at the National Bureau of Standards in Boulder, Colorado, on July 29-31 of this year. These Symposia are held as part of the activities in Subcommittee II on Lasers and Laser Materials, of the ASTM. Sub-

committee II is charged with the responsibilities of formulating standards and test procedures for laser materials, components, and devices. The Chairman of Subcommittee II is Haynes Lee, of Owens-Illinois, Inc. Co-chairmen for the Damage Symposia are Dr. Arthur Guenther, Chief Scientist of the Air Force Weapons Laboratory, and Dr. Alexander J. Glass, Head, Theoretical Studies, Y Division, Lawrence Livermore Laboratory.

Over 150 attendees at the Symposium heard 42 papers on topics relating fabrication procedures to laser induced damage in optical materials; on metal mirrors; in infrared window materials; the multipulse, wavelength and pulse length dependence of damage thresholds; damage in dielectric films and at exposed surfaces; as well as theoretical discussions on avalanche ionization and multiphoton processes of importance at shorter wavelengths. Of particular importance was the sealing relations developed from several parametric studies relating fundamental properties (refractive index, surface roughness, etc.) to the damage threshold. This year many of the extrinsic influences tending to reduce a material damage resistance were isolated such that a measure of its egregious nature could be quantified. Unfortunately, it was evident that much still needs to be accomplished to improve processing and fabrication procedures to allow a measurable approach to a materials intrinsic strength to be demonstrated. *These proceedings include the following papers (indented):*

Fabrication of laser optics at Lawrence Livermore laboratory, N. J. Brown, *SP435*, pp. 3-9 (Apr. 1976).

Key words: chamfering; continuous polishing; grinding; metal polishing; optical fabrication.

This paper summarizes fabrication techniques in use at Lawrence Livermore Laboratory for laser discs, windows, and mirrors, and polishing techniques used with metal surfaces.

Standard industrial polishing of high energy laser optics, W. J. Spawr, *SP435*, pp. 10-13 (Apr. 1976).

Key words: copper; molybdenum; optician; polishing; surfaces; zinc selenide.

The polishing and figuring of optical materials to produce state-of-the-art surface quality is truly an art, a scientific art, but an art nonetheless.

To attain success, the optician must have a clear mental model of the processes and associated techniques, and use this model as his most important tool. Second only to that is the combination of discipline and determination that no harmful or deleterious influences are allowed to effect the processes. New sophisticated polishing machines used in "Metrology Laboratory" environments are of little or no assistance. Polishing machines built 50 years ago work as well as the latest designs.

Today, moderately skilled technicians routinely produce 30 Å RMS surfaces on copper, molybdenum, and zinc selenide. These surfaces are free of orange peel, scratches, and digs; and are produced on conventional polishing machinery. Such surfaces are shown to exhibit exceedingly high laser damage thresholds from 1.06 to 10 μm. This is accomplished on a daily basis in a time frame comparable to the commercial polishing of ordinary optical glasses.

Ion planing and coating of sodium chloride, R. A. Hoffman, W. J. Lange, and W. J. Choyke, *SP435*, pp. 14-19 (Apr. 1976).

Key words: arsenic trisulphide; ion planing; protective films; moisture resistance; sodium chloride.

Ion planing of single crystal sodium chloride, using low energy Xe ions at grazing incidence, is effective in removing scratches from surfaces when the sample is rotated. Surface features which develop, probably due to defects such as polishing grit and dislocations, can be minimized and the scratches eliminated by optimizing the amount of material removed. Ion planing and depositing overcoating films "in situ" greatly improves film adherence and protection of sodium chloride substrates against moisture attack.

Polishing studies and backscatter measurements on alkali-halide windows, M. J. Soileau, H. E. Bennett, J. M. Bethke, and J. Shaffer, *SP435*, pp. 20-28 (Apr. 1976).

Key words: alkali-halide; KCl; laser windows; optical figure; polishing; scattered light; surface absorption.

Surface absorption, optical figure, and optical scatter from windows are particularly important in high energy lasers. Surface absorption can result in window failure due to thermal distortion and in some cases catastrophic failure. Excellent optical figure is required for each component in the laser system optical train in order to maintain maximum on axis intensity of the focused laser beam. Backscatter from windows and other optical components can cause depumping of the active medium, and in the case of amplified chains, catastrophic damage to the laser amplifiers. A technique for polishing alkali-halide and quantitative measurements of backscatter for alkali-halide windows from the visible to 10.6 μm will be presented. This polishing procedure produces alkali-halide surfaces which have less than 1×10^{-4} surface absorption, are parallel to less than 3 seconds of arc and are flat to better than a quarter wave in the visible. Scattering levels below 10^{-4} at 10.6 μm have been achieved.

1.06 μm 150 psec laser damage study of diamond turned, diamond turned/polished and polished metal mirrors, T. T. Saito, D. Milam, P. Baker, and G. Murphy, *SP435*, pp. 29-40 (Apr. 1976).

Key words: copper mirror; damage threshold; dark field photography; diamond turned optics; 1.06 μm polishing.

Using a well characterized 1.06 μm 150 psec glass laser pulse we have studied the damage characteristics for diamond turned, diamond turned/polished, and polished copper and silver mirrors less than 5 cm diameter. Although most samples were tested with a normal angle of incidence, some were tested at 45° with different linear polarization showing an increase in damage threshold for S polarization. Different damage mechanisms observed will be discussed. Laser damage is related to residual surface influence of the fabrication process. Our first attempts to polish diamond turned surfaces resulted in a significant decrease in laser damage threshold. The importance of including the heat of fusion in the one dimensional heat analysis of the theoretical damage threshold and how close our samples came to the theoretical damage threshold will be discussed.

Pulsed laser damage to uncoated metallic reflectors, I. Goldstein, D. Bua, and F. A. Horrigan, *SP435*, pp. 41-48 (Apr. 1976).

Key words: angle of incidence; polarization; pulsed laser damage; thermal model.

Threshold damage measurements were made on a variety of polished bulk copper and thin gold film reflectors using a TEM_{00} mode Q-switched Nd:YAG laser. Results correlate well with a simple thermal model based on the assumed existence of a critical surface temperature. Direct confirma-

tion of this thermal model was obtained through systematic variations of the polarization and angle of incidence of the incident laser beam and calorimetric measurements of the surface optical absorption coefficients. The "Damage Threshold" was defined through a careful procedure of attenuating the incident beam and varying all parameters (e.g., focus, position on the surface) until the sample no longer could be "damaged" as assessed visually with a microscope. In one striking case the damage threshold of two "identical" samples was shown to correlate with the measured surface absorption and not with the visual surface quality.

The implications of these results to the design of high power optical systems which use large angles of incidence (e.g., axicon or toric optical elements) are discussed. In particular, for the polarization associated with Brewster's phenomenon the damage threshold was found to remain constant over wide variations of the angle of incidence, e.g., from 0 to 70° or 80°.

Diamond-turned mirrors, H. E. Bennett, M. J. Soileau, and P. C. Archibald, *SP435*, pp. 49-56 (Apr. 1976).

Key words: diamond turning; laser damage; metal mirrors; micromachining; optical figure; scattered light.

Diamond-turned, micromachined metal mirrors offer a new approach to optical fabrication and may have significant advantages for use as laser components. A laser mirror must have (1) excellent optical figure, (2) low scattered light, (3) high reflectance, (4) high damage threshold, and (5) good environmental resistance. We have measured optical figures as good as 1/20th wave over a 3.86-cm diameter sample and better than a wave over a 10.2-cm diameter sample on micromachined mirrors produced by Oak Ridge National Laboratories. Scattered light levels in the infrared can be as low or lower than those obtained on conventional mirrors and values as low as 2×10^{-5} have been observed at a wavelength of 10.6 μm. Infrared reflectance values as high or higher than those of conventional evaporated or sputtered coatings have been achieved and one mirror had an absorption at 10.6 μm of 0.006. The laser damage threshold of micromachined mirrors may well be higher than that obtainable by other techniques, but this question and the environmental resistance and "coatability" of a micromachined surface require further investigation.

Results of optical measurements of surface quality and figure of diamond-turned mirrors, R. E. Sladky and R. H. Dean, *SP435*, pp. 57-65 (Apr. 1976).

Key words: blur circle; circular diffraction grating; diamond-turned mirrors; diffraction pattern; machine cusp; scattered light; surface figure.

During the past year, the Oak Ridge Y-12 Plant has diamond turned mirrors for the LASL High-Energy Laser and for other projects. The largest of these mirrors are flat, elliptical in shape, and 654 mm (25.5 in) on the major axis and 394 mm (15.5 in) on the minor axis. The concave mirrors are 394 mm OD. These mirrors were inspected for surface finish and figure. Results of this work will be summarized. In addition, blur circle was measured. Measurements of scattered light have also been made. In some cases, the diffraction pattern was related to the waves formed in the surface by the machining process. This information has been useful to the engineers doing research on the diamond turning of laser materials.

Dielectric coated diamond turned mirrors, J. R. Buckmelter, T. T. Saito, R. Esposito, L. P. Mott, and R. Standlund, *SP435*, pp. 66-74 (Apr. 1976).

Key words: adherence; diamond machining; dielectric mirror; electroplating; laser damage resistance; stress relief.

Adherence of multilayer dielectric enhanced mirror coatings to diamond turned metallic surfaces was discovered to be a problem. Initial coating results demonstrated peeling and erratic optical properties for a variety of coating designs deposited on ERDA diamond turned copper, silver, and gold. The same coating designs deposited on polished molybdenum had excellent adherence and consistent optical properties. The adherence problem was determined to derive from two factors intimately connected with the diamond turning process, namely, oil adsorption and stress in the electroplated metal surface. These factors can be eliminated by stress relief in a heated oil bath followed by thorough clening in freon or trichloroethylene prior to coating. Procedures used to investigate dielectric coated diamond turned mirrors included absorption calorimetry, damage measurements with a 10 kW laser and Auger Spectroscopy.

Slide-position errors degrade machined optical component quality, J. B. Arnold, P. J. Steger, and R. R. Burleson, *SP435*, pp. 75-89 (Apr. 1976).

Key words: controlled environment; diamond machining; machined optics; nondistortion part support; position errors; quality and compatible part material; quality diamond tools.

An ultraprecision lathe is being developed at the Oak Ridge Y-12 Plant to fabricate optical components for use in high-energy laser sytems. The lathe has the capability to produce virtually any shape mirror which is symmetrical about an axis of revolution. Two basic types of mirrors are fabricated on the lathe; namely, (1) the mirrors which are machined using a single slide motion (such as flats and cylinders), and (2) the mirrors which are produced by two-coordinated slide motions (such as hyperbolic reflectors; large, true-radius reflectors, and other contoured-surface reflectors). The surface-finish quality of typical mirrors machined by a single axis of motion is better than 13 nm, peak to valley, which is an order of magnitude better than the surface finishes of mirrors produced by two axes of motion. Surface finish refers to short-wavelength-figure errors that are visibly detectable. The primary cause of the inability to produce significantly better surface finishes on contoured mirrors has been determined as positional errors which exist in the slide positioning systems. The correction of these errors must be accomplished before contoured surface finishes comparable to the flat and cylinder can be machined on the lathe.

Ultrasonic cleaning of optical surfaces, W. E. K. Gibbs and A. D. McLachlan, *SP435*, pp. 90-97 (Apr. 1976).

Key words: laser damage; metal mirrors; subsurface structure; ultrasonic cleaning.

During the formal proceedings of the 1975 Symposium on Laser Induced Damage in Optical Materials, Dr. A. H. Guenther presented some recent results on the degradation of polished optical surfaces by ultrasonic cleaning procedures. This information was supplied to him by Dr's. W. E. K. Gibbs and A. D. McLachlan of the Materials Research Laboratories of the Department of Defense, Commonwealth of Australia. Materials studied included OFHC copper, beryllium copper, zirconium copper, stainless steel, kanigen and fused quartz. Results indicate that ultrasonic cleaning degrades polished surfaces, and if the cleaning process is vigorous enough for a sufficient duration of time,

subsurface fracture introduced in the grinding process is made quite evident. At the conclusion of the transmission of this correspondence, a discussion on the subject of ultrasonic cleaning ensued.

Thermal diffusivity of germanium gallium arsenide and cadmium telluride over the temperature range 80 K-900 K, R. Doussain, H. P. le Bodo, *SP435*, pp. 98-106 (Apr. 1976).

Key words: cadmium telluride; gallium arsenide; germanium; laser flash method; laser windows; thermal diffusivity.

The laser flash technique was used to determine the thermal diffusivity of germanium, gallium arsenide and cad um telluride over the temperature range 80 K-1000 K. The main features of the experimental equipment are described. Values of thermal diffusivity (80-900 K) are reported.

Damage to 10.6 μm window materials due to CO_2 TEA laser pulses, K. M. Leung, M. Bass, and A. G. J. Balbin-Villaverde, *SP435*, pp. 107-117 (Apr. 1976).

Key words: KCl; NaCl; pulsed CO_2 TEA laser damage; transmitted pulse; waveform distortion; ZnSe.

Laser irradiation induced damage to several materials of interest for use as 10.6 μm laser system windows was studied. A pulsed CO_2 TEA laser, operating in the TEM_{00} mode was the irradiation source in these experiments. The light was focused onto the surfaces or into the bulk of the samples and the waveform of the transmitted pulse was monitored. Comparison of the incident and transmitted laser pulse waveforms shows the onset of laser induced damage as a distortion of the latter. Damage threshold data and a discussion of possible damage mechanisms for improved ZnSe, commercial and RAP grown KCl, and commercial NaCl are presented.

Improvements in the breakdown threshold in alkali halides at 10.6 μm, V. Wang, C. R., Giuliano, S. D. Allen, and R. C. Pastor, *SP435*, pp. 118-125 (Apr. 1976).

Key words: alkali halides; bulk damage; longitudinal mode control; pulsed 10.6 μm laser damage; RAP materials; transmitted pulse cutoff; variable pulse duration.

Evidence has been found that the threshold for laser-induced breakdown in the bulk of single crystals is strongly dependent upon processing. Potassium bromide, KCl, and NaCl have been examined over a range of pulse widths (from 0.2 μs to 6 μs) in selected cases and for a variety of pulse shapes using both single longitudinal mode and partially mode-locked multilongitudinal mode pulses. A breakdown threshold of over 12 GW/cm^2 (2.5 MV/cm) for KCl far exceeds the best values obtained in previously available commercial material at these pulse lengths. A comparison of breakdown threshold for conventional and reactive atmosphere processed (RAP) halides is made with comment upon the present ambiguities in breakdown mechanism. In addition to the measurement of damage thresholds of materials from different sources, the temporal profile of transmitted pulses at the time of damage was monitored.

Optical distortion by laser heated windows, J. S. Loomis and E. G. Bernal, *SP435*, pp. 126-141 (Apr. 1976).

Key words: infrared lasers; interferometry; stress birefringence; thermal distortion; windows.

The optical distortion introduced in a collimated He-Ne beam by windows irradiated with a CO_2 laser has been measured interferometrically. Materials measured included ZnSe, KCl, NaCl, CaF_2, SrF_2, and BaF_2. Flux densities from the CO_2 laser were in the range 10-60 KW/cm^2 with total powers from 250 to 1000 watts for the ZnSe and the halides. The changes in the interferometric patterns observed can be attributed to a) isotropic phase shifts proportional to the local temperature, b) anisotropic effects due to induced birefringence that affect both the symmetry of the interferometric pattern and the visibility of the fringes, c) localized phase shifts at the entrance and exit points due to surface absorption.

An analysis of the experimental observations is given using a scalar optics approach and temperature rise functions derived previously by the authors. Experimental comparisons of thermal sensitivity of various materials are given. Also, the relative value of the anisotropic changes in optical path as the window aperture is filled at constant flux density is calculated. This result allows the prediction of window behavior in large lasers from the results of interferometric tests with focused beams of the same flux density.

Thermal distortion studies of ZnSe windows by far field irradiance measurements, J. A. Detrio and R. D. Petty, *SP435*, pp. 142-147 (Apr. 1976).

Key words: far field intensity; laser windows; thermal distortion; thermal lensing; ZnSe.

We have experimentally measured the effect of thermal lensing in ZnSe windows on the far field irradiance (at 10.6 μm) as a function of input power and absorption coefficient. These preliminary measurements are compared to the theoretical predictions of the figures of merit analysis. The undesirable effect produced by interference between reflections from the sample faces is successfully minimized by the use of wedged samples and ratiometric detection techniques. Beam slewing, which may also mask the desired data, is minimized by the use of a scanning slit at a primary mirror focus and a detector preceded by a diffuser and integrating sphere.

Spectral emittance measurements with a cryogenically cooled instrument, D. L. Stierwalt, *SP435*, pp. 149-156 (Apr. 1976).

Key words: cryogenically cooled; spectral emittance.

We have been measuring spectral emittance of laser window materials for several years. The sensitivity of our apparatus was limited not by detector noise, but by background fluctuations caused by minute fluctuations in the temperature of the instrument. Because of this limitation a new instrument has been built which operates at 77°K. This greatly reduces the background radiation and allows us to take advantage of the higher sensitivity of a cooled detector. This instrument covers the spectral region from 2.5 to 14.0 microns with a spectral resolution of about 1-1/2 percent. The noise equivalent absorption coefficient appears to be about 10^{-6} cm^{-1} at 10.6 microns and about 10^{-5} cm^{-1} at 5.0 microns.

Several samples of NaF, NaCl, and KBr have been measured at temperatures from 200°K to 373°K. A number of bands were observed in these samples, some of which have been previously reported and some have not. These spectra will be presented as well as a description of the instrument.

Surface studies with acoustic probe techniques, J. H. Parks and D. A. Rockwell, *SP435*, pp. 157-163 (Apr. 1976).

Key words: acoustic probe techniques; infrared window laser absorption; KCl absorption; laser induced damage; surface absorption.

A new measurement technique will be discussed which utilizes acoustic surface waves to detect the surface depth dependence of radiative absorption. This will include a theoretical analysis of the detection process which relates these measurements to a quantitative model of surface absorption phenomena. This technique is generally applicable to study weak surface absorption at wavelengths for which a material is essentially transparent. Surface wave phase variations induced by the absorption of 10.6 μm radiation have been measured on KCl surfaces with a laser pulse energy of only ~50 mJ. The surface absorption σ of these samples were measured by calorimetry to be $\sigma \sim 2\times10^{-4}$, and acoustic probe measurements on the same samples yielded $\sigma \sim 1\times10^{-4}$. Initial results of recent studies on both polished and etched alkali halide surfaces are discussed.

Photoelastic constants of infrared materials, A. Feldman, D. Horowitz, and R. M. Waxler, *SP435*, pp. 164-169 (Apr. 1976).

Key words: birefringence; germanium; KCl; refractive index; single crystal; stress optic constants.

Optical distortion occurs in infrared laser windows due to thermal gradients established by the absorption of high power radiation. Principal sources of distortion are the stresses produced by the thermal gradients. Because of the photoelastic effect, these stresses, which vary from point-to-point in the material, produce changes in the refractive index. We are measuring the photoelastic constants of infrared window materials. The measurements employ null techniques which have several advantages over other techniques that have been employed in the past. We present data obtained on Ge, reactive atmosphere processed (RAP) KCl, and KCl doped with KI.

Refractive index and temperature coefficient of index of CVD zinc selenide, M. J. Dodge and I. H. Malitson, *SP435*, pp. 170-174 (Apr. 1976).

Key words: refractive index; temperature coefficient of refractive index; zinc selenide.

The refractive index of each of two prismatic samples of CVD ZnSe was measured from 0.5086 to 18.2 μm by means of the minimum-deviation method on a precision spectrometer. Data were obtained at temperatures near 20 and 34 °C and each set of data was fitted to a three-term Sellmeier-type dispersion equation, which permits refractive index interpolation within several parts in 10^{-5}. Using the data obtained at the two temperatures, dn/dT was calculated for both samples. A comparison of refractive index and dn/dT is made with other types of ZnSe.

Laser window test facility, J. L. Zar, *SP435*, pp. 175-188 (Apr. 1976).

Key words: diamond absorption coefficient; laser window heating; laser window testing; Type II diamond windows.

A test facility has been constructed for testing laser window material. This utilizes the focused beam from a 15 kW CW laser at 10.6 μm or other available lasers. Provision for cooling the window is included and also instrumentation for measuring optical and mechanical effects.

The irradiated area may be varied by positioning the specimen. The beam profile is very close to Gaussian. The intensity and beam profile is given as a function of diameter and distance from the focus.

Forty-seven natural diamonds have been tested to find the correlation between the UV absorption spectrum, the IR absorption spectrum and the absorption coefficient β at 10.6 μm. Transparency at 0.253 μm is roughly correlated with low values of β. A water cooled diamond window holder is also described.

Optical material damage from 10.6 μm CW radiation, C. A. Huguley and J. S. Loomis, *SP435*, pp. 189-201 (Apr. 1976).

Key words: CO_2 laser radiation; Cu; CW laser damage; grating; infrared windows; KCl; mirror; Mo; NaCl; window; ZnSe.

Damage studies of a variety of optical materials including KCL, SnSe, NaCl, Mo, and Cu substrates were conducted. Most of the samples were substrates with optical coatings, and several were gratings. Typically, a rectangular grid of thirty irradiation sites was used. An analysis of damage thresholds was accomplished.

10.6 μm component damage from a 20 μsec rapidly pulsed laser, A. B. Callender, *SP435*, pp. 202-206 (Apr. 1976).

Key words: mirror damage; pulsed lasers; window damage.

Extrinsic lower bound thresholds have been found for some window materials and coated and uncoated metal mirrors. The results differ from single shot data in that formation of breakdown plasmas in the vicinity of the components appear to be more likely after several high repetition rate shots have been made. No major conditioning effects have been observed.

Laser damage measurements at CO_2 and DF wavelengths, J. O. Porteus, M. J. Soileau, H. E. Bennett, and M. Bass, *SP435*, pp. 207-215 (Apr. 1976).

Key words: Al mirrors; Auger spectroscopy; damage morphology; electron emission; electron imaging; ion emission; laser-induced damage; surface characterization; surface temperature.

Preliminary results from laser damage tests conducted with CO_2 and DF lasers on samples mounted in a newly constructed ultrahigh vacuum sample chamber are reported. The lasers operate single mode and the pulse lengths are 100 nsec for CO_2 and about 500 nsec for DF. A precise method of focusing which permits accurate determination of power densities is described. Incorporated in the test chamber are a scanning electron imager, an optical microscope, a profiling Auger system, and a charged particle collector for *in situ* analysis. Analytical results are presented and implications for physical damage processes are discussed. Measurements in nitrogen on aluminum samples indicate that the threshold for N_2 breakdown is reduced some 20 times in the vicinity of the aluminum surface. Laser supported gas plasma waves are formed which shield the surface, and no physical damage occurs for single 100 nsec pulses even at power levels of 10 GW/cm^2. However, in vacuum damage does occur at about the expected power levels. No significant difference between the damage threshold for polished and machined aluminum surfaces was found.

Single and multilongitudinal mode damage in multilayer reflectors at 10.6 μm as a function of spot size and pulse duration, V. Wang, C. R. Giuliano, and B. Garcia, *SP435*, pp. 216-229 (Apr. 1976).

Key words: absorbing inclusions; damage statistics; laser damage; reflectors; ThF_4; thin film; ZnSe; 10.6 μm.

An extensive series of measurements was carried out upon several high reflectivity multilayer dielectric ($ZnSe/ThF_4$) enhanced reflectors (typically 99.8%) using a CO_2 TEA laser. Measurements were made using smooth single longitudinal mode pulses, partially modelocked mul-

tilongitudinal mode pusles, and a range of pulse lengths extending from 0.6 μs to 6 μs. Studies were conducted at spot size diameters ranging from 50 μm to 255 μm. It is observed that damage thresholds are independent of pulse duration or pulse temporal shape (energy dependent) and evidence is presented that the damage is caused by inclusions, and that the average separation of inclusions, their absorption, and the film absorption can be inferred. A defect-limited damage threshold (90 J/cm^2) and a lower limit to the defect-free threshold (4.4 kJ/cm^2) for the film is established.

Temperature and wavelength dependence of the reflectance of multilayer dielectric mirrors for infrared laser applications, D. L. Decker, *SP435*, pp. 230-235 (Apr. 1976).

Key words: multilayer dielectric mirror; optical absorptance; reflectance; scattering; temperature dependence; wavelength dependence.

The absorptance of mirrors used in high energy laser applications is significant in determining the heat load which must be removed by cooling and the magnitude of the associated thermal figure distortion. For design purposes it is necessary to know the absorptance not only at room temperature, but also at temperatures up to and above the actual operating temperature of the mirror. The damage threshold is also related to the absorptance and to its variation with temperature, dA/dT. Since temperature and wavelength dependence is needed, it is most convenient to infer the absorptance from absolute reflectance and scattering measurements, rather than from direct measurement. The present paper describes instrumentation capable of making relative reflectance vs. temperature measurements with a precision and accuracy of 7×10^{-5}. Temperature dependence data over the range from 25 to 125 °C is presented and analyzed for several commercially obtained dielectric multilayer mirror designs intended for use at 3.8 μm. These mirrors have absolute reflectances above 0.997 and show a reflectance variation with temperature, $|dR/dT|$ of 5×10^{-5} or less.

Preparation and evaluation of ZnS/CeF_3 AR coatings for 10.6 micron KCl laser windows, A. Golubovic, W. Ewing, R. Bradbury, I. Berman, J. Bruce, and J. J. Comer, *SP435*, pp. 236-243 (Apr. 1976).

Key words: CeF_3; CO_2 pulsed laser damage; coating topography; KCl; laser window coatings; ZnS.

The possibility of using ZnS/CeF_3 as a 2-layer antireflection coating for 10.6 micron laser window materials was investigated. Both sputtered and sublimed layers of ZnS were deposited on well characterized Bridgman RAP grown KCl substrates. CeF_3 layers were thermally evaporated onto both bare and ZnS coated KCl substrates. The chemistry and structural quality of the coatings were examined by several characterization techniques including x-ray diffraction, electron microscopy and diffraction, scanning electron microscopy, Auger spectroscopy, Nomarski microscopy, and emittance spectroscopy. Pulsed laser damage studies at 10.6 microns were performed to evaluate the damage threshold of the coatings.

As_2S_3 coatings on KCl, A. D. Baer, T. M. Donovan, and M. J. Soileau, *SP435*, pp. 244-247 (Apr. 1976).

Key words: As_2S_3; coating deposition; index of refraction; laser windows; surface composition; 10.6 μm.

Potassium chloride (KCl) and quartz windows were coated with As_2S_3 at deposition temperatures of 80 and 22 °C. The index of refraction of As_2S_3 coatings is a function of deposition temperature for KCl windows, but not for quartz windows. Coatings deposited on KCl at 80 °C are more durable and less absorbing than those deposited at 22 °C. It is suggested that deposition temperature affects the properties of coatings on KCl because the composition of the surface of polished KCl windows changes with temperature. As_2S_3 coatings were produced with an optical absorption of 1.7 cm^{-1} at a wavelength of 10.6 μm, as compared with 1.1 cm^{-1} reported for bulk As_2S_3.

Design for high power resistance, A. L. Bloom and V. R. Costich, *SP435*, pp. 248-253 (Apr. 1976).

Key words: damage threshold; optical coatings; thin films.

The influence of materials parameters such as thermal conductivity, intrinsic stress, thermal expansivity, and Young's modulus on coating performance is discussed. Metal, metal-dielectric, and dielectric multilayer films at both 1.06 μm and 10.6 μm are considered. Calculations are presented for various combinations of coatings and substrates.

Influence of standing-wave fields on the laser damage resistance of dielectric films, B. E. Newnam, D. H. Gill, and G. Faulkner, *SP435*, pp. 254-271 (Apr. 1976).

Key words: damage thresholds; dielectric thin films; electric fields; electron-gun evaporation; picosecond pulses; rf sputtering; standing-wave patterns.

The influence of standing-wave electric fields on the damage resistance of dielectric thin films was evaluated for the case of 30-ps laser pulses at 1.06 μm. Single-layer films of TiO_2, ZrO_2, SiO_2, and MgF_2 were deposited by state-of-the-art electron-gun evaporation on BK-7 glass substrates with uniform surface preparation. The film thicknesses ranged from one to five quarter-wave increments.

The thresholds for TiO_2 films of odd quarter-wave thickness were greater than for even multiples which correlated well with the calculated internal maximum electric fields. Threshold variations for ZrO_2 films were apparent, but not as distinctly periodic with film thickness. Negligible variations were obtained for SiO_2 films, again correlating with electric-field calculations.

Additional tests allowed comparisons of thresholds for 1) back- and front-surface films for normal incidence; 2) S- and P-polarized radiation at an incidence angle of 60°; and 3) circular and linear polarizations for normal incidence. The thresholds were compared with calculated standing-wave field patterns at various locations in the films. A definite correlation was generally found between the internal field maxima and the thresholds, but in a few coatings defects apparently decreased or prevented any correlation.

Threshold ambiguities in absorptive laser damage to dielectric films, R. H. Picard, D. Milam, R. A. Bradbury, and J. C. C. Fan, *SP435*, pp. 272-283 (Apr. 1976).

Key words: damage threshold; dielectric films; heat conduction; laser damage; multiphoton absorption; rf sputtering.

The threshold energy density for laser-induced damage arising from homogeneous absorption in thin dielectric films is dependent upon the laser irradiance. This is illustrated by measurements of the time to breakdown of rf sputtered films irradiated by tightly focused square-waveform ruby laser pulses. We are able to show that the increase of threshold with decreasing irradiance is due to two mechanisms: (1) cooling of the film by conduction of heat to the substrate and (2) two-photon absorption in the film itself.

Time resolved study of laser-induced structural damage in thin films, N. Alyassini and J. H. Parks, *SP435*, pp. 284-288 (Apr. 1976).

Key words: adhesion effect; laser induced damage; optical probe technique; thin film; time resolved damage.

A time resolved optical probe technique reported previously was used to study laser induced structural damage in thin film dielectric coatings. Experimental data indicates that thin film damage frequently occurs without any detectable spark or distortion to the transmitted damaging ruby pulse and that structural damage to thin film can occur up to 40 nsec after passage of the damaging Q-switched ruby pulse through the site. In addition damage threshold of $\lambda/4$ ZnS single layer film indicates the presence of a film/substrate adhesion effect.

The importance of refractive index, number density, and surface roughness in the laser-induced damage of thin films and bare surfaces, J. R. Bettis, R. A. House, A. H. Guenther, and R. Austin, *SP435*, pp. 289-295 (Apr. 1976).

Key words: damage thresholds; laser damage; refractive index; surface damage; surface roughness; thin films.

Results of a laser-induced damage study to optical surfaces and thin-film coatings are reported. Ten different half wave films, placed on fused silica, sapphire, BK-7, and ZnSe, were subjected to 1.06 μm radiation in a 147 μm spot size. Nine different optical materials in bulk form including four glasses were also tested. The results were compared to a phenomenological equation relating threshold optical field to number density, refractive index, and root mean square surface roughness. The films were measured inhomogeneity and were deposited by r.f. sputtering, electron beam heating, and thermal evaporation. Very good correlation was obtained between predicted and observed behavior.

Investigation of the damage properties of multilayer dielectric coatings for use in high power Nd:glass lasers, C. E. Thomas, B. Guscott, K. Moncur, S. Hildum, and R. Sigler, *SP435*, pp. 298-304 (Apr. 1976).

Key words: coating damage; laser damage; mirrors; multilayer dielectric coatings; polarizers.

The development of high-power Nd:glass laser systems has reached a point where the damage in multilayer dielectric coatings limits the available energy from the laser. KMSF has initiated a testing program to identify the parameters that affect the damage levels of dielectric coatings. We will report the measured damage levels as a function of predeposition substrate cleaning, the dielectric material used (TiO_2 vs. ZrO_2), the substrate material (Pyrex vs. BK-7 or quartz), and the laser pulse length (80 to 480 picoseconds). Damage levels will be compared with the light-scattering properties of the coatings.

Correlation of laser-induced damage with surface structure and preparation techniques of several optical glasses at 1.06 μm, R. A. House, J. R. Bettis, A. H. Guenther, and R. Austin, *SP435*, pp. 305-320 (Apr. 1976).

Key words: damage thresholds; fused silica; ion polishing; surface damage; surface roughness; surface structure; thin films; ultrasonic cleaning.

An extensive experimental investigation has been conducted to correlate laser-induced surface damage with surface structural properties in a range of transparent dielectric materials. Materials investigated were Fused Silica (Corning and Optosil); BK-7 (Schott "P" quality); ED-2, ED-4, and Cervit (all Owens-Illinois). Samples were prepared using controlled grinding, conventional polishing, ion polishing, and bowl-feed polishing. Major parameters of interest were the polishing compound used, the rms surface roughness, the subsurface fracture zone, etching, flame polishing, overcoating with $\lambda/2$ of the substrate material, and the possibly deleterious effect of ultrasonic cleaning. The damaging radiation was a focused 1.06 μm laser beam of about 40 ns width in the TEM_{00} transverse mode. Target sites on a given sample were shielded from each other against blowoff and UV radiation.

Picosecond breakdown studies: Threshold and nonlinear refractive index measurements and damage morphology, W. L. Smith, J. H. Bechtel, and N. Bloembergen, *SP435*, pp. 321-330 (Apr. 1976).

Key words: avalanche ionization; dielectric breakdown; inclusions; laser damage threshold; morphology; nonlinear refractive index; picosecond laser pulses.

Single picosecond pulses from a well-calibrated Nd:YAG laser have been used to study the bulk dielectric properties of 14 transparent solids. Measured values of the breakdown thresholds and nonlinear refractive indices are presented. Photomicrographic data of the damage morphology yield information concering spatial and temporal microplasma growth from initiating electrons, and concerning the spatial density of initiating sites. The data indicate avalanche ionization is the damage mechanism. Preliminary results from a breakdown study at 0.53 μm are discussed.

Current status of electron-avalanche-breakdown theories, M. Sparks, *SP435*, pp. 331-346 (Apr. 1976).

Key words: electron-avalanche breakdown; dielectrics; frequency dependence; magnitude.

Evidence is presented that current theories of electron-avalanche breakdown in dielectrics are inadequate to explain existing data or to be predictive. Specific difficulties include the following: (1) The theoretical value of the ionization frequencies are too small, by tens of orders of magnitude in some cases, to explain the experimental damage results even when the large initial conduction electron densities in (4) below are assumed. (2) The theoretical result for the *frequency dependence* of the breakdown electric field $E_B \sim (1+\omega^2\tau^2)^{1/2}$ disagrees with experimental results. The explanation in terms of an anomalously small electron relaxation frequency is inconsistent with the value of τ required to explain the *magnitude* of E_B, with calculated values of τ (by two orders of magnitude), and with the difference between the dc and 10.6 μm experimental values of E_B. (3) The temperature dependence of E_B is incorrect. (4) The assumed value of the electron density $n_c = 10^8 - 10^{10}$ cm^{-3} required to initiate the avalanche is in conflict with results of photoconductivity measurements. Bounds on n_c set by estimates of the value of the electronic conductivity indicate that the probability of finding an electron in the focal volume during the pulse is less than 10^{-6}, possibly much less, in some cases. (5) The theories are not predictive. Tentative new theoretical results hold promise of explaining existing experiments and being predictive.

A statistical analysis of laser induced gas breakdown—A test of the lucky electron theory of avalanche formation, D. Milam, R. A. Bradbury, and R. H. Picard, *SP435*, pp. 347-355 (Apr. 1976).

Key words: electron avalanche; laser-induced gas breakdown; photoionization.

It is shown that the statistical distribution of breakdown times of gas volumes irradiated with square waveform ruby laser pulses can be explained by accounting for the probability that initial electrons are reliably produced by photoionization. Furthermore, the nature of the statistics of gas breakdown are closely related to those predicted by the lucky electron theory, and to the experimentally observed statistics of breakdown in solid dielectrics. It is suggested, therefore, that the statistics of intrinsic breakdown in both gases and solids may be related to the probability of obtaining initial charge rather than purely a manifestation of the lucky electron statistical process.

Measurement of free electron density at the onset of laser-induced surface damage in BSC-2, N. Alyassini and J. H. Parks, *SP435*, pp. 356-361 (Apr. 1976).

Key words: damage electron density; electron density transient; free electron absorption; laser induced surface damage; optical probe technique; refractive index variation.

A study of transient processes which occur during laser induced surface damage to BSC-2 glass was conducted. An optical probe technique was employed in this study which used a He-Ne laser to internally probe the surface at the critical angle. The variations in the detected He-Ne beam revealed a decrease in the site specular reflectivity which precedes structural damage by as much as 2.4 nsec. This is shown to be the result of a laser induced increase in the free electron density at the irradiated surface site with a measured average build up time of 1.6 nsec, resulting in a detectable decrease in the site refraction index ($\Delta n = 10^{-5} - 10^{-3}$). From the measured specular reflectivity decrease, a calculation of the free electron density at the onset of damage indicates a density of $10^{18} - 10^{19}/cm^3$. It is shown that the resulting free electron absorption can transfer a damaging amount of energy from the laser pulse to the sample causing at least melting of the irradiated surface site.

Multi-pulse optical damage of NaCl, P. Bräunlich and P. Kelly, *SP435*, pp. 362-365 (Apr. 1976).

Key words: avalanche breakdown, intrinsic damage; mode-locked pulse trains.

Single-shot intrinsic laser damage of NaCl at 1.06 μm is caused by avalanche ionization. The reduction of the damage threshold of an order of magnitude in case the sample is exposed to a mode-locked train of ten pulses, observed by Penzkofer, was assumed to be caused by absorbing inclusions. In this paper we show that the dependence of the damage threshold on the number of pulses in a mode-locked train can be satisfactorily explained by the avalanche breakdown mechanism.

Do multi-photon induced collision chains lead to pre-breakdown material modifications in alkali halides?, A. Schmid, P. Bräunlich, and P. K. Rol, *SP435*, pp. 366-368 (Apr. 1976).

Key words: alkali halides; collision chains; halogen emission; intrinsic damage; multi-photon absorption.

Experiments are described that indicate the existence of a new phenomenon in certain alkali halides: the multi-photon induced collision chain along [211] and [110] directions of the halide sublattice at power densities below the one-shot damage threshold. A preliminary model description of the involved physical processes is given. The sequence of events starts with the multi-photon generation of self-trapped excitons and leads, via nonradiative exciton-decay, to the formation of new color centers and/or to the ejection of atomic species from the surface. Possible implications which these pre-breakdown material modifications may have on intrinsic optical breakdown are discussed.

Multiphoton absorption coefficients in compound semiconductors from ruby to CO_2 laser wavelengths, R. A. Shatas, S. S. Mitra, and L. M. Narducci, *SP435*, pp. 369-388 (Apr. 1976).

Key words: multiphoton processes; nonlinear absorption; nonlinear optical properties; semiconductor optical properties; two-photon absorption coefficients.

A critical review of multiphoton absorption coefficients for direct band semiconductors of interest in laser optical applications is presented. The two-photon nonlinear absorption coefficients have been calculated in the second order perturbation employing interconduction band transition model of Braunstein and Ockman, two-valence band intraconduction or intravalence band transition model of Basov et al., and the Keldysh electromagnetic field "dressed" valence and conduction band wave-function model. In all models, corrections to the original calculations were needed to account for effective masses, dielectric constants and the energy band dispersion relations. Comparison of theoretical predictions at 0.694, 1.06, 1.318, and 10.6 μm laser wavelengths shows that, in general, the Basov model slightly over-estimates, the Braunstein model substantially under-estimates the nonlinear absorption, and the Keldysh model yields second order nonlinear absorption about three times larger than Braunstein. It is shown that the second order nonlinear absorption coefficient in the photon energy range $E_g/2 < h\omega < E_g$ where E_g is the forbidden gap width, can be as high as 10^{-5} cm W^{-1} and therefore under certain circumstances can exceed the linear absorption at laser flux intensities as low as 10^5 W cm^{-2}. In addition, nonlinear absorption coefficients up to the fifth order have been estimated from the Keldysh model. The utility of the Keldysh model is demonstrated by the surprisingly good prediction of the band-edge absorption in GaAs and InSb without any adjustable parameters.

Electroabsorption: A possible damage consideration, R. P. Benedict and A. H. Guenther, *SP435*, pp. 389-394 (Apr. 1976).

Key words: electroabsorption; IR optics; laser damage; multiphoton processes; uv.

Electroabsorption, also known as photon-assisted tunneling or the Franz-Keldysh effect, is the phenomenon in which the application of a large electric field produces a change in the absorption coefficient of a solid material. This effect has been proposed as a possible laser damage mechanism since the effective absorption coefficient will be dependent upon the laser intensity (optically related electric field) rather than the constant it is usually taken to be. The constant value is normally determined from low laser intensity calorimetric or emittance measurements.

A theoretical investigation of the interaction of an EM field with a material shows that the dc field limit is a tunneling effect and the high-frequency limit is multiphoton absorption so that electroabsorption is closely related to the latter. The result being that one should primarily consider multiphoton absorption rather than electroabsorption for potential damage implications in most situations. Calculations are presented that indicate the relative importance of multiphoton absorption for window materials for both visible and IR lasers. The results indicate that multiphoton absorption will usually be unimportant for IR materials except in cases of extremely high fields and no other competing

damage mechanisms. For materials used with visible lasers, the phenomenon must be considered as a potential cause of damage.

Irradiance limits for vacuum ultraviolet material failure, C. J. Duthler and M. Sparks, *SP435*, pp. 395-405 (Apr. 1976).

Key words: nonlinear index of refraction; optical distortion; thermal fracture; two-photon absorption.

Calculated values of irradiance I at which materials fail in 7.2 eV pulses of 10 nsec duration by various mechanisms indicate that metallic mirrors melt at very low values, typically I≅20 MW/cm. Improving the aluminum, which is the only good metallic vuv reflector, would increase I by a factor of only three. The lowest of the thresholds for transparent materials are ~140 MW/cm² for the intrinsic reversible process of optical distortion caused by the conduction electrons generated by two-photon absorption and ~200 MW/cm² for the intrinsic irreversible process of thermal fracture by two-photon absorption. Other thresholds are: ~1 GW/cm² for fracture from enhanced stimulated Raman scattering in Raman-active materials; ~1.6 GW/cm² for melting from two-photon absorption; ~2 GW/cm² for optical distortion from the nonlinear refractive index (bound electrons); and ~100 GW/cm² for thermal fracture from extrinsic one-photon absorption with β=0.1 cm^{-1}. Included in the calculations are the Joule heating by the generated electrons, which is greater than the direct heating by the absorption process, and electron-avalanche multiplication. Thermally induced optical distortion has a higher threshold than that for the optical distortion by generated conduction electrons.

SP438. **Testing and certification for export products in industrializing countries.** Proceedings of a Regional Seminar held at the Regional English Language Centre and International House, Singapore, May 19-20, 1975, H. S. Peiser and R. S. Marvin, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 438*, 160 pages (Feb. 1976) SD Catalog No. C13.10:438.

Key words: certification; developing countries; exports; industrializing countries; labeling; seminar; South Asia trade; testing.

A regional seminar sponsored by the Singapore Institute of Standards and Industrial Research, the National Bureau of Standards, and the Agency for International Development was held in Singapore in May of 1975. The participants represented most of the countries in South Asia concerned with increasing their exports, and concentrated on various problems connected with the testing and certification of such exports. Most of the prepared papers reviewed the practice and future plans of these countries. During the discussion a number of specific problems and issues were raised, with a good deal of attention focused on the extent to which the standards and certification of goods by an exporting country can be and are recognized by the importer. This report includes both the prepared papers and a mildly edited version of the discussions following each. *These proceedings include the following papers (indented):*

Export testing, labeling and certification – An overview, W. E. Andrus, Jr., *SP438*, pp. 9-21 (Feb. 1976).

Testing and certification of export products in the Republic of China, W. Y. F. Ning, *SP438*, pp. 23-27 (Feb. 1976).

Pre-export testing and certification in Sri Lanka, R. T. Wijewantha, *SP438*, pp. 29-34 (Feb. 1976).

Development of a National infrastructure of support services for quality control for export, M. Probine, *SP438*, pp. 45-62 (Feb. 1976).

Metrology plan for Korean industrial development, K. Zae-Quan, *SP438*, pp. 69-78 (Feb. 1976).

Can data collection and analysis reduce the rejection of exported products?, J. Hilsenrath, *SP438*, pp. 83-89 (Feb. 1976).

The institution of a worldwide integrated system of testing facilities (WISTF), F. von Ranke, *SP438*, p. 95 (Feb. 1976).

Thailand's certification and quality marks program, K. S. Stephens, *SP438*, pp. 105-124 (Feb. 1976).

Basic export inspection policy in Korea, C. Jong Wan, *SP438*, pp. 127-131 (Feb. 1976).

Testing and certification of Philippine export products, V. F. Ranoa, *SP438*, pp. 133-135 (Feb. 1976).

Certification mark and export inspection in India, A. B. Rao, *SP438*, pp. 139-141 (Feb. 1976).

Quality certification in developing countries, R. Estrada, *SP438*, pp. 143-148 (Feb. 1976).

Pre-export quality control scheme for crumb rubber: Pilot project and experience of Indonesia, N. N. Sumantri, *SP438*, pp. 149-151 (Feb. 1976).

SP439. **The Center for Building Technology: A perspective,** M. Olmert, *Nat. Bur. Stand. (U.S.), Spec. Publ. 439*, 30 pages (Jan. 1976) SD Catalog No. C13.10:439.

Key words: building research; criteria; energy; engineering; industry construction; measurement techniques; standards.

The mission of the Center for Building Technology is threefold. They are (1) advance building technology by providing technical and scientific bases for criteria and standards that improve the usefulness, safety, and economy of buildings; (2) facilitate, for the public benefit, the implementation of improved building technology by providing technical assistance to all sectors of the building community; and (3) develop improved techniques by which the end-users in buildings, communities and industrial processes conserve energy. This report presents an overview of the Center for Building Technology's research areas through its accomplishments and ongoing projects.

SP441. **Successful experiences in teaching metric.** A Conference in Celebration of the One Hundredth Anniversary of the Metric Convention, 1875-1975, held at the National Bureau of Standards, Gaithersburg, MD, May 20-21, 1975, J. V. Odom, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 441*, 115 pages (Jan. 1976) SD Catalog No. C13.10:441.

Key words: education; International System of Units; metrication; metric education; metric system; training; Treaty of the Meter.

These proceedings contain the texts of the presentations made at a recent conference on Successful Experiences in Teaching Metric. Specific experiences in introducing the metric system in all areas of educational interest were presented. These ideas will be especially useful to educators just beginning to prepare for their change to the metric system. *These proceedings include the following papers (indented):*

The International System of Units, R. W. Roberts, *SP441*, pp. 1-3 (Jan. 1976).

Principles and practices of teaching the metric system in public schools, G. W. Bright, *SP441*, pp. 4-12 (Jan. 1976).

Metric in general (elementary) education, L. Smith, *SP441*, pp. 13-15 (Jan. 1976).

Metrication and the school librarian, P. Lawrence, *SP441,* pp. 16-17 (Jan. 1976).

Teaching the metric system through television and other audio visual means, N. F. Calhoun, *SP441,* pp. 18-22 (Jan. 1976).

Metric and mathematics education, S. A. Choate, *SP441,* pp. 23-29 (Jan. 1976).

Experiences in teaching the metric system in science classes, B. Logan, *SP441,* pp. 30-42 (Jan. 1976).

Metric gaming, C. R. Trueblood and M. Szabo, *SP441,* pp. 43-50 (Jan. 1976).

Metric in preservice teacher training, J. Lindbeck, *SP441,* pp. 51-54 (Jan. 1976).

Constructing metric education workshops—A model, P. T. Larsen, *SP441,* pp. 55-62 (Jan. 1976).

Metric for the blind, A. Nadash, *SP441,* pp. 63-66 (Jan. 1976).

Metric in sports and physical education, F. Burgee, *SP441,* pp. 67-68 (Jan. 1976).

Metrication and State departments of education, A. V. Buffington, *SP441,* pp. 69-71 (Jan. 1976).

Metrication in a local education agency, T. E. Rowan, *SP441,* pp. 72-76 (Jan. 1976).

Successful experiences in teaching metrics in home economics, C. A. Ford, *SP441,* pp. 81-84 (Jan. 1976).

Successful experiences in teaching metric conference, E. M. Schanbacher, *SP441,* pp. 85-89 (Jan. 1976).

A basis for successful teaching of vocational metric education, R. A. Dieffenderfer, *SP441,* pp. 90-96 (Jan. 1976).

What can we learn from the English and Australian experiences in metric education?, A. B. Chalupsky, *SP441,* pp. 97-100 (Jan. 1976).

SP442. **Report of the 60th National conference on weights and measures 1975,** S. J. Edgerly, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 442,* 272 pages (May 1976) SD Catalog No. C13.10:442.

Key words: calibration; communication; consumers; grain moisture measurement; laws and regulations; measurement; metric; packaging and labeling; police radar equipment; standards; supermarket automation; weights and measures.

This is a report of the proceedings (edited) of the Sixtieth National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in San Diego, California, July 13-18, 1975, and attended by state, county, and city weights and measures officials, the Federal Government, business, industry, and consumer organizations. *These proceedings include the following papers (indented):*

Guarding measurement integrity, S. D. Andrews, *SP442,* pp. 1-6 (May 1976).

Preparing for a metric America, F. K. Willenbrock, *SP442,* pp. 6-12 (May 1976).

Petroleum—Engineering, measurement, marketing, J. Byrne, *SP442,* pp. 14-25 (May 1976).

Why not unshackle measurement standards, L. T. Wallace, *SP442,* pp. 25-28 (May 1976).

Intergovernmental communication mechanisms, R. J. Barra, *SP442,* pp. 29-35 (May 1976).

The State of California measurement system, S. Kozich, *SP442,* pp. 36-42 (May 1976).

Calibration of police radar instruments, D. W. Allan, *SP442,* pp. 42-47 (May 1976).

Grain moisture measurements and the weights and measures community, F. E. Jones, *SP442,* pp. 52-58 (May 1976).

Impact of electronics in weighing, J. J. Elengo, Jr., *SP442,* pp. 59-65 (May 1976).

Weights and measures and the consumer, M. H. Becker, *SP442,* pp. 67-72 (May 1976).

Representing the consumer interest in weights and measures law enforcement, H. E. Nelson, *SP442,* pp. 74-80 (May 1976).

Supermarket automation—UPC and the computerized checkout counter, T. K. Zaucha, *SP442,* pp. 83-98 (May 1976).

Maintaining an economic balance during inflationary times, K. J. Simila, *SP442,* pp. 104-110 (May 1976).

Overview of consumer issues, C. A. Barrett, *SP442,* pp. 115-121 (May 1976).

The perfect formula and PMTD, A. J. Farrar, *SP442,* pp. 123-133 (May 1976).

American society for testing and materials—Voluntary consensus standards, W. T. Cavanaugh, *SP442,* pp. 133-137 (May 1976).

International organization of legal metrology—The emerging U.S. role, W. E. Andrus, Jr., *SP442,* pp. 138-156 (May 1976).

Converting to metric standards in Canada, J. L. Armstrong, *SP442,* pp. 156-163 (May 1976).

SP443. **Hydraulic research in the United States and Canada, 1974,** G. Kulin and P. H. Gurewitz, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 443,* 359 pages (June 1976) SD Catalog No. C13.10:443.

Key words: fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1973-1974 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

SP444. **Wind and seismic effects.** Proceedings of the Sixth Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, National Bureau of Standards, Gaithersburg, MD, May 15-17 (1974), H. S. Lew, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 444,* 462 pages (Apr. 1976) SD Catalog No. C13.10:444.

Key words: bridges; buildings; codes; disaster; dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; wind.

The Sixth Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects was held in Washington, D.C., on May 15-17, 1974. The proceedings of the Joint Meeting include the opening remarks, the program, the formal resolutions, and the technical papers. The subject matter covered in the papers includes extreme winds in structural design: assessment and experimental

techniques for measuring wind loads; dynamics of soil structures and ground response in earthquakes; structural response to wind and earthquakes and design criteria; disaster mitigation against natural hazards; and technological assistance to developing countries. *These proceedings include the following papers (indented):*

On the gust response of long-span suspension bridges, N. Narita and K. Yokoyama, *SP444,* pp. I-1 – I-20 (Apr. 1976).

Key words: bridge; design; field data; gust response; model; specifications; structure; theory; wind.

In the design of above-ground structures it is established practice to consider the effects of wind. For some structures, like long-span suspension bridges, the influence of wind may be the primary design control which will then govern the inherent safety of the structures and the final construction cost.

This paper, therefore, will describe the required changes in design specifications to incorporate the influence of gusts on long-span suspension bridges.

The necessary numerical calculations are illustrated in addition to some long-term observations on the Kanmon Bridge. The importance and necessity of studies on gust response are emphasized.

Extreme winds in hurricanes and possibility of modifying them, R. C. Gentry, *SP444,* pp. I-21 – I-33 (Apr. 1976).

Key words: cloud seeding; frequency distribution; hurricanes; typhoon; wind; wind intensities.

A hurricane (or similar storm called by other names) is the most destructive of nature's phenomena. This is partly because of the extreme winds associated with the storms (ranging up to 320 kilometers per hour), but also because the winds may continue blowing for several hours, and they are accompanied by rising ocean water, strong along-shore currents, and torrential rains.

Discussions will be presented of the frequency of hurricanes of various intensities, the rate at which the wind speeds decrease after the storm crosses the coast and moves inland, the effect of the winds on the storm surge, and the variation of the wind speed with height.

For several years, members of the United States Government have been experimenting to reduce the maximum intensity of the winds of hurricanes. Summaries will be presented of the progress and future prospects for this work.

Extreme winds in the United States, A. R. Hull and P. E. Hughes, *SP444,* pp. I-34 – I-39 (Apr. 1976).

Key words: building code; damage classification; extreme wind; tornado; wind loads.

The highest winds reported in the United States have been associated with tornadoes. Fujita (1971) has developed a tornado windspeed/damage classification system which permits extreme wind estimations without follow-up surveys. Fujita classifications of tornadoes for the 1965, 1971, and 1972 seasons, as well as extreme wind values associated with thunderstorms and extratropical cyclones during 1973 are reviewed as they relate to ANSI building code requirements for design loads. Next, a new observational tool, an acoustic, doppler-shift "sonar" capable of profiling low-level wind regimes at the actual building site, is briefly described. Finally, the proposed NOAA Severe Environmental Storms and Mesoscale Experiment (SESAME) is examined. SESAME is an observational/research effort to identify the processes and controlling parameters of extreme-wind generating severe weather systems such as squall lines, thunderstorms, and possibly tornadoes, and to aid in the development of conceptual and numerical models of these phenomena.

Wind tunnel experiments for studying a local wind, K. Suda, S. Soma, and K. Takeuchi, *SP444,* pp. II-1 – II-20 (Apr. 1976).

Key words: bridge; gust; meteorological data; topographical model; wind load; wind profile; wind tunnel.

In general, the study of the effects of local winds on structures is primarily based on data obtained from wind tunnel experiments. As an example of such studies, an investigation of air flow around Nakatojima Island relative to the wind resistant design of a long suspension bridge has been conducted and will be presented.

However, it is not reasonable to conduct such a study entirely related to wind tunnel experiments, as the similitude rule has not been established. Therefore, field observations have been made in parallel with the wind tunnel experiments and the data obtained by both sources are then compared. Thus, the results obtained from the wind tunnel experiment are more reliable.

A study of wind pressures on a single-family dwelling in model and full scale, R. D. Marshall, *SP444,* pp. II-21 – II-51 (Apr. 1976)

Key words: aerodynamics; boundary layers; buildings; codes and standards; wind loads; wind tunnels.

Wind pressures measured on a single-family dwelling are compared with results obtained from a 1:50 scale model placed in a turbulent boundary layer. It is shown that the fluctuating components of surface pressures far exceed the mean or steady pressures and are well correlated over sizeable roof areas. The consistently low fluctuating pressure coefficients obtained from the wind tunnel model are attributed to improper simulation of the lower portion of the atmospheric boundary layer. Comparisons between actual loads and specified design loads suggest that certain current provisions are marginal for tributary areas and excessive for localized areas such as ridges, eaves and corners. A procedure for expressing loads on both localized and extended roof areas in terms of mean pressure coefficients and a peak factor is described.

Nonlinear calculations of ground response in earthquakes, W. B. Joyner, A. T. F. Chen, and P. C. Doherty, *SP444,* pp. III-1 – III-12 (Apr. 1976).

Key words: elastic medium; engineering seismology; ground layer; numerical solution; shear wave.

The response of soil to strong earthquake motion involves a high degree of nonlinearity. Because of the difficulties in solving the nonlinear problem, most calculations of ground response are currently made by a method – variously characterized as "equivalent linear", "quasi-linear", or "strain-compatible" – that assumes the true solution can be approximated by the response of a linear model whose properties are chosen to accord with the average strain that occurs in the model during excitation. The average strain level is determined by iterative calculation. To solve the nonlinear problem directly, we have developed algorithms by which the hysteretic behavior of an individual soil element can be efficiently modeled in a computer. The algorithms enable us to model any reasonable set of hysteresis loops of the Masing type that laboratory experiments may dictate. We are experimenting with various numerical techniques for integrating the basic nonlinear differential equations, includ-

ing the method of characteristics as described by Streeter, Wylie, and Richart. A comparison was made between the equivalent linear and the nonlinear solution (using the method of characteristics) for a 200-meter section of firm alluvium excited at its base by the N21E component of the Taft accelerogram multiplied by four. This excitation produced peak strains of several tenths of a percent. The nonlinear solution showed substantially higher spectral levels of response at five percent damping for periods between 0.1 and 0.6 seconds.

Observation and analysis of ground response in earthquakes, S. Hayashi and H. Tsuchida, *SP444,* pp. III-13 – III-23 (Apr. 1976).

Key words: earthquake; field data; ground response; seismic waves; seismometer; soil-structure interaction.

In the field of port and harbor engineering, the ground response due to earthquakes is generally considered. However, there are many problems at present in idealization of the surface layer, input ground motions, and nonlinear behavior of the soil. In order to provide some design data in these areas, research has been conducted using six downhole seismometer arrays established in port areas in Japan. Typical observed acceleration time histories have been obtained and are shown and compared with those calculated by the multiple reflection theory. In order to investigate ground response relative to structures of large length, such as a tunnel, a two-dimensional seismometer array has been established. Examples of the considerations of the ground response required in practice are seen in microzonation in the earthquake proof design of a subaqueous tunnel.

Research study on liquefaction, W. F. Marcuson, III, *SP444,* pp. III-24 – III-37 (Apr. 1976).

Key words: earthfill dams; earthquakes; ground shaking; liquefaction; soil density; stability.

A research program is being undertaken by the U.S. Army Corps of Engineers to evaluate the liquefaction phenomena relative to earthquake response of earth-filled dams. Present and future studies are summarized.

Estimation of liquefaction potential by means of explosion test, K. Yamamura and Y. Koga, *SP444,* pp. III-38 – III-51 (Apr. 1976).

Key words: earthquake; explosion test; ground strength; ground vibration; liquefaction; pore-water pressure.

A series of field vibration experiments were performed in order to estimate the liquefaction potential of sandy soil during earthquakes. Bore hole explosions were used as a vibration source. A significant relation was found between the ground stiffness and the pore-water pressure as caused by the explosion. A proposed method has been developed for estimation of the liquefaction potential.

Landslide incidence and mechanisms during earthquakes, G. E. Ericksen, *SP444,* pp. III-52 – III-71 (Apr. 1976).

Key words: avalanches; earthquakes; falls; flows; landslides; mechanisms; slides.

Strong earthquakes affecting mountainous terrain are generally accompanied by hundreds or even thousands of large potentially destructive landslides of certain types; earthquakes affecting areas of low relief cause fewer and generally different types of landslides, which, however, may be equally destructive to works of man. On steep slopes, among the many types of landslides that may occur, falls, slides, and avalanches of rock and soil are most frequent during earthquakes. These landslides take place where slides are commonly part of normal mass-wasting processes that affect hillslopes; the earthquake causes the reactivation of old slides as well as the formation of new slides. Surface movement on faults may also cause landslides by the formation of scarps that change slope stability although landslides of this type are relatively rare. In terrain of low relief, failures by rotational slump, translatory sliding, and lateral spreading are frequent causes of destruction in towns and cities that have been constructed on unstable, generally water-saturated soil or unconsolidated sediment.

Landslides, with the exception of those classified as falls, result from failure of earth materials under shear stress. Earthquake accelerations trigger landslides by causing a transitory increase in shear stress in earth materials at the site of the slide, and by causing a decrease in the shear strength of certain materials, such as water-saturated soil. Most slide failure takes place along one or more planes of weakness, except for flow or landspreading, wherein a given mass fails by loss of coherence. Among the most spectacular or earthquake-triggered landslides are large high-speed debris avalanches that move over a cushion of entrapped compressed air.

Stress condition effects on dynamic properties of soils, E. Kuribayashi and T. Iwasaki, *SP444,* pp. III-72 – III-83 (Apr. 1976).

Key words: damping; damping coefficients; shear modulus; soil; tests; torsional excitation.

In the engineering field, the evaluation of the dynamic characteristics of soils and foundation subgrades has been required in the course of studying vibrational problems and especially problems associated with earthquake engineering. The dynamic characteristics of soils have, therefore, been obtained by laboratory tests, using a resonant column method. These tests were conducted to evaluate the shear modulus and the damping characteristics in dry and saturated specimens of various soils in Japan.

The hollow cylindrical samples tested were 25 cm in height, 10 cm outside diameter, and 6 cm inside diameter. This arrangement permitted a more uniform deformation of the sample cross-section. The specimens were fixed at the bottom, and at the top of the specimens oscillators were fastened to a rigid mass, which supply a torsional vibrational force to the system. A confining pressure, which was applied equally to the outside and inside of the test sample, was supplied by air pressure. An axial load was also applied, and was independent of the confining pressure in order to produce an anisotropic stress condition.

After the sample was prepared and all proper alignments and forces imposed, the frequency of the torsional excitation was introduced and then varied until the oscillator specimen system resonated. The resonant frequency varied from 40 cps to 100 cps, depending upon the dimensions and density of the sample and the applied stress condition and the shearing strain amplitude. The strain amplitude varied from 5×10^{-6} to 5×10^{-4} for these tests. The shear moduli were calculated from the resonant frequencies and the other parameters, as given above. The damping characteristics were obtained by using the amplitude-time decay response curves of the free vibrations.

In the triaxial state of stress, the mean principal stress, p, is defined by $(\sigma_a+2\sigma_r)/3$ and the deviator stress, q, is given by $\sigma_a-\sigma_r$ are the axial and radial stresses, respectively. The

test results indicate the following trends for the dynamic properties of soils;

(1) Under constant values of the other parameters, the shear moduli vary with 1/2 power of p and decreases with an increase in the void ratio and shearing strain amplitude. Furthermore, the damping capacity decreases with an increase in p and also increases with an increase of strain amplitude. However, the damping capacity remains constant irrespective of the change in the void ratio, when the other parameters remain constant.

(2) When the value of p is kept constant, the shear moduli are nearly constant irrespective of the value of q until the stress ratio, q/p, reaches a value of about 1.0. However, beyond this value of q/p, the shear moduli begin to decrease with an increase in q/p. This phenomenon is due to the anisotropic stress condition and the corresponding anisotropy in the inner structure of specimens.

Prediction of maximum earthquake intensities for the San Francisco Bay Region, R. D. Borcherdt and J. F. Gibbs, *SP444,* III-84 – III-94 (Apr. 1976).

Key words: earthquake; empirical relation; Franciscan Formation; geological character; ground shaking; intensity.

The intensity data for the California earthquake of April 18, 1906, are strongly dependent on distance from the zone of surface faulting and the geological character of the ground. Considering only those sites (approximately one square city block in size) for which there is good evidence for the degree of ascribed intensity, the empirical relation derived between 1906 intensities and distance for 761 sites underlain by rocks of the Franciscan Formation is

$$\text{Intensity} = 2.30 - 1.90 \log (\text{Distance}).$$

For sites on other geologic units intensity increments, derived with respect to this empirical relation, correlate strongly with the Average Horizontal Spectral Amplifications (AHSA) determined from 99 three-component recordings of ground motion generated by nuclear explosions in Nevada. The resulting empirical relation is

$$\text{Intensity Increment} = 0.27 + 2.70 \log (\text{ASHA}).$$

Resulting average intensity increments for various geologic units are −0.29 for granite, 0.19 for Franciscan Formation, 0.64 for other pre-Tertiary, Tertiary bedrock, 0.82 for Santa Clara Formation, 1.34 for Older Bay sediments, 2.43 for Younger Bay mud. These empirical relations have been used to delineate areas in the San Francisco Bay region of potentially high intensity from future earthquakes on either the San Andreas fault or the Hayward fault.

A statistical approach to loading and failure of structures, R. G. Merritt, *SP444,* pp. IV-1 – IV-15 (Apr. 1976).

Key words: failure; probability theory; random process; safety; statistical analysis; structural engineering.

A fundamental problem of structural engineering is the examination and selection of loading criteria. It is imperative that any solution to the problem center around a rationale that relates information available on loading to selected criteria. Such available information is generally in the form of data. It is the purpose of this brief paper to abstract the problem and outline preliminary work on a rationale for addressing the problem.

The paper begins by defining the general nature of the problem. Solution to the problem is related to consideration of available information in the form of data. The next three sections of the paper discuss the initial stages of a rationale for consistent examination and selection of loading criteria. The first of the sections examines available information on structural load and the second examines available information on instances of structural failure. Classes of statistical methods are discussed in the third section. This section also includes discussion of a proposed method for assessing the overall information content of the available data. Finally, several illustrative examples of application of statistical methods to load and failure data are presented and the paper concludes with a discussion of future extension to this preliminary work.

Synthetic experimental research on the ductility of short reinforced concrete columns under large deflection, K. Nakano and M. Hirosawa, *SP444,* pp. IV-16 – IV-36 (Apr. 1976).

Key words: column; ductility; earthquake; reinforced concrete; shear tests; structural engineering; web reinforcement.

In general, short reinforced concrete columns will fail in a brittle manner. In order to create and establish better ductility in such columns, a synthetic research experimental program has been conducted. This program consisted of the testing of 125 short column specimens, subjected to multicycles of flexure-shear loadings. The result from these tests indicate the following:

1) The ductility of structural members is influenced by shear, bond, and buckling of the compression bars.

2) To prevent buckling of compression reinforcement, under small curvature, the spacing of the web reinforcement must be controlled.

3) In order to prevent a shear failure of structural members within reasonable ductility, an effective set of restrictions on the combination of axial force, tensile reinforcement ratio, and shear span ratio are required.

4) The bond failures which were observed in the test members, where deformed bars were used as axial reinforcement, consisted of bond-splitting of the cover concrete. The conventional method, which uses bond strength as an index to verify bond failure, is not effective for the bond-splitting failure mode. It is, therefore, necessary to restrict the tensile reinforcement ratio in order to prevent this type of bond failure.

Nonlinear analysis of a guyed tower, S. K. Takahashi and W. A. Shaw, *SP444,* pp. IV-37 – IV-54 (Apr. 1976).

Key words: finite element; guyed tower; structural analysis; structural engineering; vibration analysis; wind load.

The Civil Engineering Laboratory has performed an analysis of a tower at a Naval communication facility. The tower is about 600 feet high and is guyed at three levels. The upper guy level contains twelve wires; the middle and lower guy levels have three wires each. The guy wires had numerous large electrical insulators attached, each weighing 510 pounds.

A nonlinear finite element analysis of the guyed tower was conducted. Separate finite elements were used for portions of the tower and the guy wires were modeled with a truss element. Deflections, forces, and stresses in the tower and guy wires were determined from dead load and an equivalent static wind load corresponding to 90 miles per hour.

Eigenvalue solutions were obtained for the first five mode shapes and natural frequencies of one of the top guy wires; the guy wire had concentrated masses at five different locations and was initially prestressed.

A standard for the structural integrity of prefabricated

dwellings, K. Nakano, M. Hirosawa, and T. Murota, *SP444,* pp. IV-55 – IV-69 (Apr. 1976).

Key words: earthquake; housing; performance specification; prefabricated dwelling; standards; structural design.

In 1973, the Ministry of Construction of Japan presented a standard for the performance of prefabricated housing. The purpose of this standard was to provide consumers with an index for selecting their dwellings. The standards are related to fire, heat, sound, durability, and structural safety against earthquakes, winds, snow, etc.

The criteria for evaluating structural properties are outlined in this paper, as well as the history and present status of prefabricated dwellings in Japan. A typical prefabricated structural system is shown in the last section.

An analytical model for determining energy dissipation in dynamically loaded structures, J. F. McNamara and S. K. Sharma, *SP444,* pp. IV-70 – IV-89 (Apr. 1976).

Key words: analytical model; dynamic analysis; dynamic loading; earthquake; energy dissipation; finite element; seismic response; structural engineering.

An analytical procedure is developed which predicts nonlinear cyclic structural response under large reversals of plastic strains. The structure is discretized by means of the finite element approximation, and the material behavior is simulated by a refined analytical model which describes the realistic hysteretic stress-strain curves of A36 steel under arbitrary cycles of load. In order to test the validity of this material model, some comparisons are made with experimental values of the inelastic response of a simply supported beam under cyclic bending. The model is subsequently used in the dynamic analysis of a portal frame subjected to a selected portion of the El Centro NS earthquake acceleration record. The improved cyclic response with the current approach is illustrated by comparing results with those obtained using a simple bilinear kinematic hardening material approximation. Comparisons are also made with values obtained using a commercially available nonlinear frame analysis computer program. Some final comments are made regarding the rate of solution convergence with integration time step size for two different temporal integration operators used in this analysis.

Design of pile foundations subjected to lateral loads, M. Nagao, T. Okubo, K. Komada, and A. Yamakawa, *SP444,* pp. IV-90 – IV-112 (Apr. 1976).

Key words: design; earthquake; highway bridges; lateral loads; pile head; piles; structural engineering.

This report presents a number of basic items relative to the design of pile foundations subjected to lateral loads, and deals with the present design status of highway bridges in Japan. Also presented are items to be further studied for the design standardization of pile foundations subjected to lateral loads. Such problems as the deformation mechanism of group-pile structures are examined.

This report presents the method by reinforcement of the pile-head.

Comprehensive seismic design provisions for buildings, C. G. Culver, *SP444,* pp. IV-113 – IV-126 (Apr. 1976).

Key words: building codes; buildings; design; earthquakes; structural engineering.

A review of the development of earthquake design provisions for U.S. building codes is presented. Suggested revisions to the current provisions are noted. A cooperative project directed toward developing comprehensive seismic design provisions is described. The organizational structure for the project including a breakdown of the Task Committees required to develop the provisions and work statements for each Task Committee are included.

Wind loading and modern building codes, E. Simiu and R. D. Marshall, *SP444,* pp. IV-127 – IV-144 (Apr. 1976).

Key words: building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind loads.

The differences between the dynamic alongwind response, the gust factors, and the total alongwind response obtained using various current procedures may in certain cases be as high as 200, 100, and 60 percent, respectively. The purpose of this paper is to investigate the causes of such differences. To provide a framework for this investigation, the paper presents an overview of the questions involved in determining alongwind structural response, and a critical description of the basic features of procedures currently in use. A comparison is made between alongwind deflections of typical buildings selected as case studies, calculated by both new and traditional procedures, some of which are described in various building codes. The reasons for the differences between the respective results are pointed out. The procedures were evaluated on the basis of a recently developed method which utilizes a logarithmic variation of wind speed with height above ground, a height-dependent expression for the spectrum of the longitudinal wind speed fluctuations. The method also allows for realistic cross-correlations between pressures on the windward and leeward building faces.

Seismic retrofitting of existing highway bridges, J. D. Cooper, R. R. Robinson, and A. Longinow, *SP444,* pp. V-1 – V-24 (Apr. 1976).

Key words: design; earthquakes; highway bridges; retrofitting; soil-structure interaction; structural engineering.

The retrofitting of existing highway bridges, to provide an added measure of protection against collapse due to earthquake ground motion, is of great importance. This interest heightened in the United States following the San Fernando earthquake of 1971, which caused extensive damage to a number of modern freeway structures.

Some of the specific concepts for retrofitting to be explored include: (1) widening of bearing supports, (2) motion restrainers across hinges, (3) ties across expansion joints, (4) the elimination of expansion joints, and (5) adding ties or reinforcing to existing columns.

The monetary savings, resulting from an effective retrofit program in preventing collapse of structures, would far exceed the cost of the research involved in generating feasible and practical retrofit details.

This is a progress report on research which will result in mathematical techniques to identify the seismically vulnerable bridge details and a catalog of retrofit techniques. Such techniques will permit strengthening of such weak links, in the total structure integrity.

Dynamic tests of structures using a large scale shake table, S. Inaba, *SP444,* pp. V-25 – V-34 (Apr. 1976).

Key words: dynamic tests; earthquake simulator; shake table; structural engineering; tests.

Since 1970, a large scale shake table located at the National Research Center for Disaster Prevention (NRDP) has been widely used for the dynamic testing of structures.

This paper presents the results of some of those dynamic tests, using this jumbo earthquake simulator, and the results obtained from some other shake tables operated by other research institutes in Japan.

A methodology for evaluation of existing buildings against earthquakes, hurricanes and tornadoes, H. S. Lew and C. G. Culver, *SP444*, pp. V-35—V-49 (Apr. 1976).

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornadoes, wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural hazard conditions and to estimate the amount of expected damage. Damage to structural building components resulting from the extreme environments encountered in earthquakes, hurricanes, and tornadoes is considered. The methodology has the capability of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. Three independent but related sets of procedures for estimating damage for each of the natural hazards are included in the methodology. The first set of procedures provides a means for qualitatively determining the damage level on the basis of data collected in field surveys of the building. The second set utilizes a structural analysis of the building to determine the damage level as a function of the behavior of critical elements. The third set is based on a computer analysis of the entire structure. All three sets of procedures are based on the current state-of-the-art. The procedures are presented in a format which allows up-dating and refining.

Experimental research on the aseismic characteristic of spherical steel tank for liquid petroleum gas, K. Nakano and M. Watabe, *SP444*, pp. V-50—V-62 (Apr. 1976).

Key words: dynamic analysis; earthquake; seismic design; seismic response; spherical tanks; structural design.

The results of static and dynamic tests on a spherical steel tank are given in detail. A theoretical technique to explain the "sloshing" effect is presented. A proposal for a safer design procedure to replace the present aseismic design practice is presented.

Research on minimizing earthquake structural damage to single-family dwellings, W. J. Werner, *SP444*, pp. V-63—V-65 (Apr. 1976).

Key words: building codes; construction practices; damage; earthquake; houses; residential dwelling.

This paper discusses proposed research work to be carried out by the Applied Technology Council of the Structural Engineers Association of California under the sponsorship of the Department of Housing and Urban Development. The objective of the project is to develop a manual of recommended construction practice for earthquake resistive dwellings, for use primarily by builders, building officials, field inspectors, plan checkers, and designers.

The manual is intended to explain the structural behavior of single-family dwellings and townhouses subjected to forces produced by earthquake shocks, illustrate the HUD Minimum Property Standards, building code earthquake requirements and sound practical construction methods and details for the reduction of single family dwelling damage. The paper discusses the need for this research, the various tasks the contractor will perform, and the final products expected to be achieved by the research program.

Earthquake engineering research supported by the National Science Foundation, C. C. Thiel, *SP444*, pp. V-66—V-79 (Apr. 1976).

Key words: earthquake engineering; grant; RANN; sponsorship; structural engineering.

A summary of earthquake engineering research work conducted by various researchers throughout the United States under the sponsorship of the National Science Foundation is presented.

The wind engineering program, M. P. Gaus, *SP444*, pp. V-80—V-82 (Apr. 1976).

Key words: research programs; sponsorship; wind engineering.

A summary of wind engineering research work conducted by various researchers under the sponsorship of the National Science Foundation is presented.

Preliminary report on present status and development project of volcanological observation and research in Indonesia, A. Suwa, *SP444*, pp. VI-1—VI-15 (Apr. 1976).

Key words: field observation; Indonesia; Japan; technical aid; volcanoes.

Indonesia has about 130 active volcanoes and their eruptions are characterized by dangerous violent explosions, nuee ardente, and volcanic mud-flows. The Geological Survey of Indonesia (GSI), Ministry of Mines, has, therefore, been carrying out observations and surveillances of volcanic activities throughout the country.

The Government of Japan, in response to a request from the Government of Indonesia, has decided to give assistance in this field of science in the framework of the Colombo Plan. The Overseas Technical Cooperation Agency (OTCA), the executing agency for the Government of Japan, has, therefore, dispatched a preliminary survey mission, headed by the author of this report, Akira Suwa, of the Japan Meteorological Agency to Indonesia in 1972.

The mission stayed in Java and Bali from November 22 to December 23, 1972, and visited the Ministry of Mines at Djakarta, the GSI at Bandung, and eight active volcanoes (eleven observatories) in order to study the possible scope of cooperation in Volcanology between Japan and Indonesia. The mission recognized two serious problems in Indonesia: deficiency of experts in volcanology, and shortage of up-to-date volcanological instruments.

Therefore, the recommendation by the preliminary survey mission to both governments was as follows:

1. Dispatch for several years the following Japanese experts to Indonesia; a. Instrumental seismologist, b. Volcano physicist; c. Volcanological geologist/petrologist.
2. Train junior volcanologists of the GSI in Japan.
3. Provide Indonesia with the following instruments; a. Seismographs for permanent and temporary observations; b. Instruments for petrological and mineralogical laboratory.

Use of stabilized adobe block and cane in construction of low-cost housing in Peru, S. G. Fattal, *SP444*, pp. VI-16—VI-24 (Apr. 1976).

Key words: adobe; cane; earthquake; housing; Peru; technical aid.

A description of the use of adobe block and cane for construction of low-cost housing in seismic areas of Peru is described.

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A comment on the technological aid to developing countries, M. Nagao and T. Okubo, *SP444,* pp. VI-25–VI-31 (Apr. 1976).

Key words: earthquake; Japan; natural disaster; storm; structural engineering; technological aid.

This paper describes the technological aid required in developing countries, after a natural disaster, as observed by the writer during surveys of storm and earthquake disasters in these developing countries.

The writer classifies the aid required after a natural disaster into three categories, that is, emergency aid, technological aid, and economic aid. The problems related to the scientific and technological areas in the developing countries after a natural disaster are discussed.

The technological aid is classified into short and long term aid.

Finally, the problems related to the required technological aid are discussed and then the necessary Governmental policy which has been prepared for implementation of a low-cost and disaster resistant housing system is described.

SP445-1. **The National Measurement System for Time and Frequency,** A. S. Risley, *Nat. Bur. Stand. (U.S.), Spec. Publ. 445-1,* 72 pages (June 1976) SD Catalog No. C13.10:445-1.

Key words: atomic frequency standards; aviation industry; electric power industry; National Measurement System, position location; shipping and boating industries; Standards laboratories; telephone industry and specialized carriers; time and frequency; time scales; users of NBS radio broadcasts.

The results of a study of the National Measurement System for Time and Frequency are given. The system is viewed from three vantage points: 1) The *Instrumentation* that provides sources of time and frequency (T&F). 2) The *Suppliers and Users* of T&F. 3) The *Calibration hierarchies* for T&F sources. An attempt is made to determine the technological, scientific, economic, and social effects of the system. Predictions are made about possible important changes in the system. The past, present, and possible future position of NBS in the system is described in detail.

SP446. **Building technology project summaries,** M. Olmert, *Nat. Bur. Stand. (U.S.), Spec. Publ. 446,* 108 pages (May 1976) SD Catalog No. C13.10:446.

Key words: building research; building technology; codes; criteria; project summaries; standards; technical bases.

The Center for Building Technology provides the technical and scientific bases for criteria and standards that improve the usefulness, safety, and economy of buildings while conserving building materials and energy. The Center's activities support the building technology program of the Federal, State and local government; assists design professions, building officials and the research community by developing design criteria that improve buildings; and assists manufacturers of building products by developing criteria for evaluating innovative building materials. This report summarizes the Center's projects for calendar year 1975. It enables individuals to get a clear impression of CBT research activities.

SP447. **Weights and measures standards of the United States—A brief history,** L. V. Judson, *Nat. Bur. Stand. (U.S.), Spec. Publ. 447,* 44 pages (Mar. 1976) SD Catalog No. C13.10:447.

Key words: history of measurement standards; measures; metric system; standards; units of measurement; weights.

Two publications of the National Bureau of Standards, now out of print, that deal with weights and measures have had widespread use and are still in demand. The publications are NBS Circular 593, The Federal Basis for Weights and Measures (1958), by Ralph W. Smith, and NBS Miscellaneous Publication 247, Weights and Measures Standards of the United States—A Brief History (1963), by Lewis V. Judson.

To meet the current demand for information on the history of weights and measures in the United States, Miscellaneous Publication 247, referred to above, updated where needed to bring it into accord with current usage, is reprinted in this publication, together with a brief addendum that discusses important events involving weights and measures of the period 1963-1975. NBS Circular 593 is not being reprinted because of the significant overlap of material treated in the two publications.

SP448. **Automation technology applied to public service.** Proceedings of a Conference on Automation Technology Applied to Public Service, held at the National Bureau of Standards, Gaithersburg, MD, May 21-22, 1974, E. G. Johnsen, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 448,* 87 pages (Sept. 1976) SD Catalog No. C13.10:448.

Key words: automation technology; economic impact of automation; productivity improvement; public services; social impact of automation.

The Conference on Automation Technology Applied to Public Service, held in May 1974, was cosponsored by the National Bureau of Standards, the General Accounting Office, the National Science Foundation and the Urban Institute. The objectives of the conference were first, to explore the use of automation technology as a means of increasing the efficiency of Government in providing higher quality public services at lower cost; and second, to explore the political, social and economic aspects involved in managing the public service applications of automation. Potential uses of automation technology discussed include automating operations in environments hazardous to safety and health of people, such as fire fighting, and the automation of services that are tedious, boring or demeaning for people to do. The spectrum of potential applications of automation technology in public service ranges from garbage collection to aids to the handicapped and from water treatment process control to the adaptive computerized regulation of traffic in urban areas. Some participants warn that the way in which automation technology is applied must be carefully thought out and supervised in order to minimize disruptive economic and social effects. *These proceedings include the following papers (indented):*

Introductory address, R. M. Davis, *SP448,* pp. 1-4 (Sept. 1976).

Keynote address: Automation Technology: Key to public service productivity improvement, T. D. Morris, *SP448,* pp. 5-7 (Sept. 1976).

Economic and social view of automation: A labor view of automation technology, M. Roberts, *SP448,* pp. 8-9 (Sept. 1976).

Technology, humanity and the cities, L. H. Blair, *SP448,* pp. 9-10 (Sept. 1976).

Session I: Automation for urban public service operations, J. M. Carlson, C. F. Guarino, W. W. Isman, M. G. Stragier, D. S. Wasserman, and J. McManama, *SP448,* pp. 11-19 (Sept. 1976).

Session II: Automation for occupational welfare, J. H. Stender, R. L. Atwood, W. E. Bradley, W. R. Knowles, and R. J. Straw, *SP448,* pp. 20-28 (Sept. 1976).

Session III: Automation for the handicapped, J. M. Benjamin, Jr., K. R. Ingham, E. Kwatny, W. G. Holsberg, and J. S. Albus, *SP448,* pp. 29-35 (Sept. 1976).

Session IV: Recovery of ocean resources for public benefit, A. Spilhaus, M. G. Johnson, A. Mucciardi, E. J. Beck, R. W. Uhrich, G. Guenther, and R. H. Cassis, Jr., *SP448,* pp. 36-43 (Sept. 1976).

Session V: Recovery of underground resources for public benefit, W. B. Schmidt, W. C. Helt, and B. M. Goldwater, Jr., *SP448,* pp. 44-48 (Sept. 1976).

Session VI: Impact of automation on the public, W. Lepkowski, B. Bova, J. McCarthy, J. S. Albus, D. V. DeSimone, L. K. O'Leary, M. MacCoby, and G. Tyler, *SP448,* pp. 49-59 (Sept. 1976).

Session VII: Automation for transportation, R. H. Cannon, Jr., C. R. Peterson, J. D. Ward, D. Roos, and D. L. Cooper, *SP448,* pp. 60-64 (Sept. 1976).

SP449. **Chemical kinetics of the gas phase combustion of fuels. (A Bibliography on the Rates and Mechanisms of Oxidation of Aliphatic C_1 to C_{10} Hydrocarbons and of Their Oxygenated Derivatives),** F. Westley, *Nat. Bur. Stand. (U.S.), Spec. Publ. 449,* 138 pages (Oct. 1976) SD Catalog No. C13.10:449.

Key words: bibliography; chemical kinetics; combustion; free radicals; gas phase; hydrocarbons; oxidation; oxygen; oxygenated organic compounds; ozone.

A reaction oriented list of references is provided for papers and reports containing rate data for gas phase reactions of combustion and oxidation of aliphatic saturated or unsaturated C_1 to C_{10} hydrocarbons, alcohols, aldehydes, ketones, ethers, peroxides and their free radicals. The list also includes decomposition, disproportionation, atom transfer and recombination reactions of the oxygen containing species noted above. Pyrolytic reactions of hydrocarbons and their radicals are excluded. All the processes listed here have been reported to occur in the gas phase combustion of fuels. In addition, a list of critical reviews dealing with the reaction kinetics of the above processes and a list of papers dealing with generalized mechanisms of the same reactions are also included. More than 800 papers covering 540 reactions are listed. The period covered extends from 1902 through June 1975.

SP451. **Data base directions. The next steps.** Proceedings of the Workshop of the National Bureau of Standards and the Association for Computing Machinery, held at Fort Lauderdale, FL, Oct. 29-31, 1975, J. L. Berg, Ed., R. G. Canning, D. L. Adams, R. W. Bemer, G. Dodd, R. M. Gall, and C. D. Trigg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 451,* 175 pages (Sept. 1976) SD Catalog No. C13.10:451.

Key words: auditing; cost/benefit analysis; data base; data base management; DBMS; government regulation; management objectives; privacy; security; standards; technology assessment; user experience.

What information about data base technology does a manager need to make prudent decisions about using this new technology? To provide this information the National Bureau of Standards and the Association for Computing Machinery established a workshop of approximately 80 experts in five major subject areas. The five subject areas were auditing, evolving technology, government regulations, standards, and user experience. Each area prepared a report contained in these proceedings. The proceedings provide guidance on steps managers should follow to prepare themselves and their organization for the installation of data base management concepts. The auditing working panel noted the increased vulnerability of organizations who integrate their formerly dispersed and redundant files into a data base and suggest actions to address this risk. The technology report noted several promising parallel developments but concluded that the future would see evolving, rather than revolutionary data base progress. Government regulations, particularly the drive for individual privacy rights, were seen to play an important role in determining data base directions and the panel's guidance on cost impact suggest that organizations would experience reduced costs with data base technology. Standards pervaded all issues and were found necessary in several sub-areas of data base technology but the panel saw no immediate likelihood of national data base standards. The user experience working panel noted that data base systems had impacted their organizations to the extent of reconsidering existing data flows, areas of responsibilities, and procedures. *These proceedings include the following papers (indented):*

Introduction, R. G. Canning, General Chairman, *SP451,* pp. 1-2 (Sept. 1976).

A manager's viewpoint, D. B. Magraw, Keynote Speaker, *SP451,* pp. 3-11 (Sept. 1976).

What experience has taught us, R. M. Gall, Chairman, *SP451,* pp. 13-28 (Sept. 1976).

Standards: A data base imperative, R. W. Bemer, Chairman, *SP451,* pp. 31-39 (Sept. 1976).

Auditing the data base, D. L. Adams, Chairman, *SP451,* pp. 41-64 (Sept. 1976).

Impact of government regulations, C. D. Trigg, Chairman, *SP451,* pp. 67-78 (Sept. 1976).

Data base technology—Present and future, G. Dodd, Chairman, *SP451,* pp. 81-103 (Sept. 1976).

Background, *SP451,* pp. 105-106 (Sept. 1976).

SP452. **MFPG—The role of coatings in the prevention of mechanical failures.** Proceedings of the 23d Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, MD, Oct. 29-31, 1975, T. R. Shives and W. A. Willard, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 452,* 199 pages (Sept. 1976) SD Catalog No. C13.10:452.

Key words: barrier film; chemical coatings; failure prevention; mechanical failure; metal coatings; plated coatings; polymer coatings; solid film lubricants; sputtered coatings; wear.

These Proceedings consist of a group of eighteen submitted papers and discussion from the 23d Meeting of the Mechanical Failures Prevention Group which was held at the National Bureau of Standards in Gaithersburg, Maryland on October 29-31, 1975. The central theme of the Proceedings is the Role of Coatings in the Prevention of Mechanical Failures, with emphasis on polymer coatings, metal coatings, solid film lubricants, and chemical coatings. *These proceedings include the following papers (indented):*

The friction and wear of polymeric coatings on metal, K. C. Ludema, *SP452,* pp. 3-13 (Sept. 1976).

Key words: adhesion; coatings; friction; metal; polymers; wear.

Polymeric coatings on metals wear and/or debond when rubbed. Information on wear is available from tests using bulk polymers which usually have a different structure than do thin films. The bond strength requirements for rubbing

surfaces appear to be greater than that developed by the technology centered in adhesives and composite materials industries. Many of the factors involved in wear life and bonding are summarized in the paper. Recent and broad ranging references are given for each of the major points in the paper.

Performance studies of polymer processed mechanical and structural components, M. J. Devine, *SP452,* pp. 14-24 (Sept. 1976).

Key words: components, structural; dry powder painting; mechanical and structural components; polymer processed mechanical and structural components; structural and mechanical components.

A technique which has become known as "dry powder painting" is one of the major advances made in the application of coatings. This technique is based upon the deposition of specially formulated, thermoplastic or thermosetting, heat-fusible powders on metallic substrates. Since there are no solvents present, the coating can be cured immediately after application. One of the most obvious advantages of this method is the absence of pollution and safety problems associated with organic solvents that are used in most liquid paint systems. A second advantage is that coatings may be obtained by this process from materials that cannot be applied by liquid paint techniques because of their poor solubility in organic solvents. Dry powder techniques are readily adaptable to current production methods and are easily learned by product finishing personnel. Because of special requirements in particle size, particle size distribution, and other properties, dry powder coatings are generally more expensive than liquid paint systems. However, in view of the advantages of dry powder processes over wet painting techniques the overall cost differences are probably minimal. In addition as much as 95 percent of the dry powder material can be utilized if a powder recovery system is used.

Advantages similar to those reported for dry powder techniques are also claimed for electrocoating. This process can be compared to electroplating of metals, and, like the dry powder method, it also avoids the use of organic sovents.

Nylon 11 as a lubricant and corrosion preventative coating, R. G. Baker, G. H. Kitchen, and R. R. Wells, *SP452,* pp. 25-30 (Sept. 1976).

Key words: abrasion; corrosion protection; friction; marine environment; powder coating; salt water; solid lubrication.

The working bearing surfaces of Sea Plow IV, a vehicle designed to lay cable in a 4-ft trench in the ocean floor, must be protected from corrosion, internal friction plus abrasion from sand, mud and silt. Examination of this problem suggested that a coating of nylon 11, applied electrostatically as a dry powder, could afford protection against all of these conditions. Conventional application techniques were modified to permit application of the coating at dockside. Results have been excellent as evidenced by Sea Plow IV's more than one year of troublefree operation.

Mechanical design concepts for coated nuclear fuel particles, J. M. Tobin, *SP452,* pp. 31-42 (Sept. 1976).

Key words: computer modeling on a microscale; elastoplastic micropressure vessels; failure predictability through small size; microencapsulated coated fuel particles.

Retention of fission products in microspherical coated particles depends upon the mechanical integrity of the coatings. Mechanical design concepts have been developed over a 15-year period which led to the fabrication of highly successful multiple coated particles such as the TRISO coated particles. An overview of this development is described.

Nickel-phosphorus alloy coatings for wear resistance, C. E. Johnson, F. Ogburn, *SP452,* pp. 45-55 (Sept. 1976).

Key words: auto-catalytic nickel; auto-catalytic nickel, hardness of; auto-catalytic nickel, wear of; electroless nickel; electroless nickel, hardness of; electroless nickel, wear of; nickel, auto-catalytic; nickel, electroless; nickel-phosphorus alloy; wear resistant alloy.

Electroless nickel coatings are nickel alloys generally with a nominal composition of 8 wt percent phosphorus, applied to metal substrates from a nickel solution by an autocatalytic chemical process. They are used for protecting steel from corrosion and wear, and are generally more corrosion and wear resistant than electroplated nickel.

Heat treatments can increase significantly the wear resistance and hardness of electroless nickel. This occurs by precipitation hardening and the precipitation of a nickel phosphide. The hardness depends on the heat treatment and on the alloy composition and often attains a Knoop hardness of 900-1000, equivalent to the hardness of electrodeposited chromium.

Tests by several laboratories show improved wear resistance with appropriate heat treatment and in some circumstances, the electroless nickel coatings have a higher wear resistance than electrodeposited chromium. Wear resistance of electroless nickel can also be improved by the incorporation of small particles and hard material into the coating during the plating process.

Chromium deposit structure has a profound influence on properties, W. H. Safranek, *SP452,* pp. 56-63 (Sept. 1976).

Key words: corrosion; crack-free chromium; electroplating; fast plating; fatigue strength; grinding; hardness; stress; tensile strength; wear.

The optimum structure of chromium electroplate should be specified for each individual application. Crack-free chromium supplies good corrosion protection and good wear resistance for some applications. Customary hard chromium is preferred for resisting wear in other applications. High-crack-count chromium is mandatory for avoiding harmful effects on the fatigue strength of high-strength steel substrates. Each of these structures can be deposited by a new process that is 25 to 50 times faster than the customary rate for chromium plating.

Plated coatings for electric contacts, M. Antler, *SP452,* pp. 64-71 (Sept. 1976).

Key words: contact lubrication; corrosion inhibitors; electrical contacts; gold plate; palladium; polymer in gold; porosity in gold; solder plate; tin-nickel alloy; tin plate; underplatings for gold; wear of gold.

Electrical contacts, such as those in separable connnectors, are required to have low and stable contact resistance. For high reliability connector applications in low voltage circuits, gold is the preferred contact material because of its chemical inertness. Recent studies have shown that the most common gold electrodeposits, which contain cobalt or nickel as hardeners, are complex materials, containing 10 percent or more by volume of organic polymers, potassium compounds, and other substances. Failure in service can occur if the deposit is porous, since films may form on the

surface by reaction of the base substrate metal with air pollutants at pore sites. The use of underplatings and smooth substrates can reduce the thickness of gold required for low porosity; inhibitor coatings may suppress corrosion reactions, and galvanically inert substrates can even eliminate pore corrosion. Wear-induced porosity is also a failure process, and contact lubrication is effective in its control. Degradation by diffusion of substrate metals, such as copper, to the surface where films form is controlled by barriers, like nickel underplate. The high cost of gold has led to the search for alternate contact materials. Palladium plate and the soft base metals, tin and solder plate, have achieved limited acceptance.

Compatibility effects when soft metals are used as solid lubricants, E. Rabinowicz, *SP452*, pp. 72-83 (Sept. 1976).

Key words: compatibility; electropolated soft metal film coatings; metallurgical; metals; soft metals; solid lubricants.

The purpose of this study has been to test, mainly by means of metal cutting experiments, the extent to which the wear life of electroplated soft metal film coatings is governed by the metallurgical compatibility between the coating and the other sliding surface. Experiments have been carried out using hard steel tools coated with various soft metals, and cutting a number of different workpiece metals. Two different configurations were used, namely milling and shaping, and in some cases the lubricant was only applied once at the beginning of the test, while in other cases it was reapplied continuously. It was found that long tool life resulted when the soft metal had low metallurgical compatibility with the workpiece material but not otherwise. The other parameter investigated, namely relative mechanical strength between film and substrate was found to be much less significant. This is in contrast to the case of the friction coefficient, which has been found to be greatly influenced by the mechanical strength ratio.

Reduction of sliding wear by metallic coatings, S. Jahanmir and N. P. Suh, *SP452*, pp. 84-93 (Sept. 1976).

Key words: coatings, metallic; metallic coatings; sliding wear.

The role of soft metallic coatings in sliding wear has been examined experimentally. The results indicate that the tribological behavior of soft coatings is consistent with the delamination theory of wear, especially the critical nature of the plating thickness. It is shown that a reduction in wear rate of three orders of magnitude is possible when the coating material is softer than the substrate and thinner than a critical thickness. The optimum plate thickness was found to be less than 1 μm for cadmium, silver, gold or nickel plated on various steels. As the plate thickness is increased, wear by delamination within the plate occurs. Environmental effects are important in coating utilization.

The search for factors to prevent mechanical failures due to corrosion with solid film lubricants, M. K. Gabel and M. B. Peterson, *SP452*, pp. 97-105 (Sept. 1976).

Key words: corrosion; electrochemical; lubricants; salt-spray.

The failure of mechanical components of contemporary flight vehicles has frequently been attributed to the corrosion characteristics of solid film lubricants. An ongoing program at the Naval Air Development Center is investigating how some parameters affect corrosion between solid film lubricants and various aircraft alloys. This paper will summarize some of the findings of this study.

Rust-inhibited nonreactive perfluorinated polymer greases, J. Messina, *SP452*, pp. 106-119 (Sept. 1976).

Key words: chemisorption; corrosion preventives; inhibitor additives; LOX compatible greases; nonreactive lubricants; rust inhibited perfluoro greases; surface chemistry lubrication.

Perfluoroalkylpolyether fluids thickened with polytetrafluoroethylene were studied in connection with the development of rust-inhibited chemically inert greases for liquid-fueled rocket engines. It was found that 1.0 to 3.0 wt percent of a physically and chemically modified organophilic dimethyloctadecylbenzyl ammonium bentonite + sodium nitrite imparts very effective rust-preventive properties to perfluoro polymer grease mixtures. Data are given which show that the rust-inhibited greases are nonreactive on contact with conventional fuels and oxidizers, exhibit lubricating properties comparable to soap-thickened greases with a significant improvement in extreme pressure properties, and are nonreactive at high impact energies in the presence of LOX. The results of this work are applicable to all liquid-fueled rocket engines for missiles and space vehicles.

The role of coatings in the prevention of erosion damage, A. P. Thiruvengadam and A. A. Hochrein, Jr., *SP452*, pp. 120-123 (Sept. 1976).

Key words: adhesion; cavitation; coatings; design charts; elastomers; erosion; Hopkinson pressure bar apparatus; impedances; mismatching; stress wave interactions; substrates; tearing; vibratory apparatus.

Among the various methods available for protection against cavitation erosion, elastomeric coatings offer great potential. However, adhesion failures, tearing, and substrate mismatching are some of the problems to be solved for a successful application of protecting coatings. Basic studies in understanding this problem includes stress-wave interaction analysis, controlled experiments with a vibratory cavitation erosion apparatus and the generation of high strain data with the help of a Hopkinson pressure bar apparatus. It is hoped that such a coordinated approach would lead to the design and development of successful coating systems.

Solid film lubricant to prevent fretting damage in titanium engine components, B. D. McConnell, *SP452*, pp. 124-131 (Sept. 1976).

Key words: curing agent; fretting; silicone resin; solid lubricants; titanium; wear.

An air drying solid film lubricant originally developed for applications in the field has been found to be an excellent coating for prevention of fretting damage in titanium-titanium mated parts. This film, designated AFSL-41, is composed of molybdenum disulfide (MoS_2) and antimony trioxide (Sb_2O_3) carried in a methyl phenyl silicone binder. The film air dries without heat through the use of a curing agent, an amino-alkyl alkoxy-silane. A brief description of the formulation is presented along with laboratory evaluation data comparing its antifretting performance with other candidate materials. The performance on titanium led to its consideration as a candidate antifretting coating for titanium components. The various screening tests used to determine antifretting properties are described along with results which led to AFSL-41 being selected for full scale engine tests. Current use of AFSL-41 by two gas turbine engine manufacturers on a production basis is discussed and the types of applications (over 100 in one engine) are described.

A study of solid lubricated gears at elevated temperatures, A. J. Haltner, D. K. Snediker, K. E. Demorest, and G. C. Marshall, *SP452,* pp. 132-148 (Sept. 1976).

Key words: fluoride films; gears; molybdenum disulfide; solid lubricants; wear.

An experimental study has been made of the performance of advanced, state-of-the-art solid lubricants applied to spur gears expected to operate to high temperatures in reusable space vehicles (space shuttle). Tests of Inconel 718 gears covered the range 25-482 °C in air, and the lubricants studied included MoS_2 in several binders (glass, metal matrix, polyimide, and polyphenylene) and mixed fluoride compositions. All of the combinations demonstrated acceptable wear over portions of the temperature range, but the glass bonded films showed the most promise—particularly at higher temperatures.

Vapor deposition of wear-resistant coatings, W. J. Wilson, M. F. Browning, and J. M. Blocher, Jr., *SP452,* pp. 151-169 (Sept. 1976).

Key words: chemical; coating; deposition; vapor; wear.

Vapor deposition processes by which a variety of wear and environment resistant coatings are applied are described. Criteria for selecting coating/substrate systems are discussed in the light of economic and technological changes.

Several examples of vapor-deposited, wear-resistant coatings are given in addition to specific examples of commercial applications.

Barrier films for miniature bearings, M. K. Bernett and H. Ravner, *SP452,* pp. 170-176 (Sept. 1976).

Key words: barrier films; bearings; fluorinated polymers; lubricant migration; lubricants; spreading prevention.

Miniature bearings (less than 30 mm O.D.) are employed in large numbers by the Navy in synchro-servo motors, guidance systems and general instrument use. The most frequent cause of malfunction of these mechanisms is bearing lubricant failure; in the majority of instances, failure is induced by migration of the lubricant away from the balls and races, both during storage and service. As a result of long-term basic studies at NRL on wetting and spreading of liquids, a low-energy, nonwetting "barrier film" was developed, which when applied to bearing race surfaces, effectively prevented migration of the lubricant. The increasing use of these films has resulted in major reductions in replacement costs and maintenance, and has significantly increased the reliability of the mechanisms involved.

Potential of sputtered coatings for improved gas bearing instrument performance, L. L. Fehrenbacher, B. D. McConnell, C. Pellerin, and K. R. Mecklenburg, *SP452,* pp. 177-186 (Sept. 1976).

Key words: antimony trioxide; friction; molybdenum disulfide; spin axis gas bearings; sputtered coatings; surface characterization; wear life.

Sputtered coatings were applied to I-400 beryllium substrates to determine and eventually optimize their friction and wear performance relative to their potential for gas bearing inertial instrument applications. Solid lubricant-carbide basecoat combinations were sputter deposited under varying conditions of substrate bias and thicknesses. The surface morphology and chemistry of the coatings were characterized prior and after friction and wear evaluations using scanning electron microscopy and scanning Auger microscopy techniques. The friction and wear tests consisted of sliding a 1/8 inch TiC ball under load on the coated disc specimens rotating at 60 RPM. MoS_2-Sb_2O_3 solid lubricants were deposited on TiC, WC and B_4C sputtered undercoats at varying thicknesses and sputtering conditions. The solid lubricant combinations exhibited consistent wear life behavior showing moderate and strong dependency on the substrate bias and solid lubricant thickness, respectively, regardless of the underlying substrate. Correlations between coating chemistry, morphology, sputtering conditions and friction and wear performance are given.

Ferrography of polymer formation under lubricated rubbing contact—An exploratory investigation, A. A. Reda, *SP452,* pp. 187-191 (Sept. 1976).

Key words: ferrographic analysis; lubricated rubbing contact; polymer formation.

Ferrographic analysis of lubricant samples from a variety of operational machines and test rigs has revealed the presence of nonmetallic particles. Some of these particles have characteristic shapes and are composed of polymers. For example, under relatively high load nonmetallic particles shaped like rolling pins were formed when a lubricant per specification Mi 1-L-23699 was used. The same particles were produced when polyphenyl ether was used as a lubricant.

It was speculated that under the conditions of the test the lubricant forms a polymeric film at the rubbing surfaces and it is rolled in the shape of rolling pins when it is pealed off. Furey has shown that polymer films are formed directly on rubbing surfaces and that these films are a factor in reducing wear. Furthermore, it is well known that different additive packages in lubricants meeting the same specifications lead to different wear rates under identical load conditions. It was considered useful to determine if ferrography could provide further information on the phenomena and to assess if ferrographyic analysis could be used to study the performance of lubricants.

SP453. **Ultrasonic tissue characterization.** Proceedings of a Seminar held at the National Bureau of Standards, Gaithersburg, MD, May 28-30, 1975, M. Linzer, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 453,* 274 pages (Oct. 1976) SD Catalog No. C13.10:453.

Key words: absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; ultrasound; velocity.

An international Seminar on Ultrasonic Tissue Characterization was held at the National Bureau of Standards on May 28-30, 1975. The meeting was cosponsored by the National Bureau of Standards, the National Science Foundation and the National Institutes of Health. This volume contains extended versions of 20 of the 21 talks presented at the Seminar. Topics covered include techniques for measurement of ultrasonic tissue parameters, the dependence of tissue properties on physical and biological variables (*e.g.,* ultrasonic frequency, temperature) and pattern recognition techniques. *These proceedings include the following papers (indented):*

The NSF (RANN) integrated program on medical ultrasonics, G. B. Devey, *SP453,* pp. 7-10 (Oct. 1976).

Key words: applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; R & D in-

centives; tissue characterization; tissue signature; ultrasonic diagnosis; ultrasound.

Recommendations made by the National Foundation (NSF) Survey Team on Ultrasonic Imaging for the conduct of a Medical Instrumentation Experiment to provide incentives to commercial firms and for the preparation of an R & D agenda for future developments in medical ultrasonics have been implemented. Projects emphasizing substantial improvements in resolution of medical ultrasonic images and investigations into ultrasonic tissue characterization are listed at high priority. The NSF (RANN) Instrumentation Technology program supports research in these areas. In addition to having good potential for making substantial technological advances, the funded projects must also develop the criteria which should be met before results of the research are introduced into clinical medicine. Successful results from a coordinated research and development program in ultrasonic tissue characterization could revolutionize medical diagnosis.

Challenges and opportunities in ultrasound, J. M. Reid, *SP453,* pp. 11-17 (Oct. 1976).

Key words: diagnosis; Doppler effect; optimization; resonance; scattering; tissue characterization; tissue parameters; tumor detection; ultrasound.

The scientific study of the ultrasonic properties of tissue is on the threshold of being able to contribute useful knowledge needed to improve the utility of ultrasonic medical diagnostic instruments. There is ample evidence to support these contentions and to guide our future course.

Ultrasonic attenuation, absorption, and velocity in tissues and organs, F. Dunn, *SP453,* pp. 21-28 (Oct. 1976).

Key words: absorption; attenuation; mammalian tissues; tissue parameters; ultrasound; velocity.

Propagation relations for compressional waves in isotropic, elastic media are described briefly and discussed with reference to ultrasonic propagation in biological structures. A selected review of experimentally obtained results from tissues and organs is presented. It is shown that characterization of tissues and organs by their acoustic parameters should be possible.

The scattering of ultrasound by tissues, J. M. Reid, *SP453,* pp. 29-47 (Oct. 1976).

Key words: blood; cross-section; diagnosis; scattering; standardization; tissue characterization; ultrasound.

Most ultrasonic diagnostic equipment is based on the observation of the waves scattered by tissues. Although these instruments generally perform useful clinical diagnosis, they do not provide quantitative measurements of the detailed characteristics of the scattered waves. Such measurements should significantly improve the diagnostic capability of medical ultrasound. The properties responsible for scattering have been shown to be differences in compressibility and density between adjacent tissue structures. The rationale of scattering measurements is considered through a review of direct measurements and substitution techniques which correct for wave shape changes. The necessity of correcting for apparatus parameters and the effects of overlying tissue attenuation is considered. Equations are derived which relate the scattered power to the scattering parameters of tissues and the measuring equipment constants for a number of useful cases.

Use of pattern recognition for signal processing in ultrasonic histopathology, K. Preston, Jr., *SP453,* pp. 51-59 (Oct. 1976).

Key words: analog-digital converter; A-scan; digitization; pattern recognition; speech spectrogram; ultrasound.

New developments in high-speed electronics have made possible real-time digitization of the ultrasonic A-scan as a block of binary words. This makes computer processing of such blocks feasible using techniques previously developed in time-series analysis for communications, speech processing, word recognition, etc. The research reported here is concentrating on: (1) advanced digitization techniques having variable block length and skip-block capability; (2) application of speech spectrogram representation and analysis to A-scan processing; and (3) use of human audition (of the recorded A-scan, properly frequency-translated) to assist in defining the features most useful for A-scan pattern recognition.

Quantitative A-scan analysis of normal and cirrhotic liver, P. N. T. Wells, R. A. Mountford, M. Halliwell, and P. Atkinson, *SP453,* pp. 61-70 (Oct. 1976).

Key words: A-scan; attenuation; computer analysis; impedance; liver cirrhosis; ultrasonics.

The development of quantitative methods of analyzing ultrasonic liver scans is reviewed. These methods are based on measurements of intrahepatic echo amplitudes or echo spacings. Simple techniques indicate that the echo amplitude tends to be increased in cirrhosis. Using a frequency of approximately 1-5 MHz, this was confirmed by computer analysis of the measurements of 100 consecutive cycles of the ultrasonic echo wavetrains in each of 30 separate scans from each of 30 individuals with normal livers, and 13 with cirrhosis. These data were acquired manually. In cirrhotics, the mean echo amplitude was 6 dB greater than in normals. Similar results were obtained with an automated system of data acquisition. The results are compatible with a model in which the observed structure is a random noise effect; the dimensions of the pulse determines the scale of the fluctuation which is observed. The echoes from cirrhotic liver, higher in amplitude but otherwise very similar to those from the normal, could be due to similar targets with greater characteristic impedance mismatches.

Digital A-scan analysis in the diagnosis of chronic splenic enlargement, K. J. W. Taylor and J. Milan, *SP453,* pp. 71-78 (Oct. 1976).

Key words: A-scan analysis; digital; grey-scale ultrasound; spleen; splenomegaly.

Before the availability of grey-scale ultrasound machines, signal processing only permitted the display of the layer echoes which were specularly reflected at large discontinuities of acoustic impedance. The enhanced signal-to-noise ratio inherent in the grey-scale technique permits, in addition, the display of the internal structure of soft tissue. The amplitude of these low-level echoes is relatively independent of beam orientation and appears to be more dependent on the nature of the interface so that the pattern of the tissue may be specific to each pathology. From clinical observations, high-level echoes are usually associated with benign causes of splenic enlargement, while cellular infiltration, as in many malignancies, results in decreased echo amplitude. Digital A-scan analysis concerns and quantitates this difference.

Attenuation and velocity measurements in tissue using time delay spectrometry, D. H. Le Croissette and R. C. Heyser, *SP453*, pp. 81-95 (Oct. 1976).

Key words: attenuation; phase; swept frequency; time delay spectrometry; tissue; transmission; velocity.

A practical ultrasound system is described which is capable of making measurements of attenuation and velocity in tissue as a function of frequency. This method is based upon a technique known as Time Delay Spectrometry which employs a swept frequency signal and has the ability to provide anechoic ultrasonic measurements. A system operating between 2 and 3 MHz has already been shown to be capable of producing images in soft tissue with a resolution of less than 2 mm. Preliminary measurements on excised tissue using this system have indicated a frequency dependence of attenuation in pathological tissue that is substantially different from that of normal tissue. The method generates the time domain response simultaneously with the received frequency sweep. It is shown that the time response in the apparatus is available as a displayed phasor quantity and that the arrival time of the directly-received signal can therefore be measured to within a few nanoseconds.

Methods of tissue identification by ultrasonic spectra, A. Sokollu, E. W. Purnell, E. Holasek, W. Jennings, and A. Kaya, *SP453*, pp. 97-107 (Oct. 1976).

Key words: color-coded B-scan; Fourier transform; spectral analysis; tissue structure; ultrasound.

Ultrasonic spectral characterization of tissue is based on the retrieval of latent frequency information not normally detected in intensity-modulated B-scan displays. The results of tissue studies and tissue-model studies are presented and discussed. A method for color coding this frequency information into a B-scan display for clinical use is described.

Algebraic reconstruction of spatial distributions of refractive index and attenuation in tissues from time-of-flight and amplitude profiles, J. F. Greenleaf and S. A. Johnson, *SP453*, pp. 109-119 (Oct. 1976).

Key words: acoustic attenuation; acoustic velocity; breast tumor; computerized tomography; heart; reconstruction; refractive index; synthetic focus; tissues; ultrasound.

Two-dimensional distributions of refractive index and attenuation were measured in transverse sections through intact isolated organs, using reconstruction techniques. Profiles of time-of-flight (TOF) and/or amplitude of 10 MHz pulses through the specimen were obtained by rectilinearly scanning two opposing transducers along either side of the specimen in the plane of interest. The received pulses were digitized at a rate of one 8-bit sample per 10 ns for 512 samples, and were analyzed with a computer algorithm which calculated the TOF of the pulse to within $\pm$ 10 ns and/or its amplitude. Typically, 256 measurements of TOF and/or amplitude were made in each profile scan for each of 37 angles of view separated by 5°. TOF's through tissue, normalized by TOF through water, were used to calculate velocity and, hence, refractive index within the specimen, using an algebraic reconstruction technique (ART). A similar approach was taken to calculate attenuation distributions. Images obtained represented acoustic velocities and/or attenuation in individual cross sections within the tissue specimen with a resolution of 64 by 64 elements ($< 2mm^2$). The disadvantage of TOF and attenuation reconstruction is that transmission scanning is required. Advantages over B- and C-scan imaging are: (1) dynamic changes in receiver gain are not required; (2) attenuation occurs on only one traversal through tissue; and (3) the absolute values of important acoustic parameters (velocity and attenuation) are determined which may have significant diagnostic value.

Measurement of ultrasonic tissue characteristics by direct and phase-contrast imaging, R. S. Mezrich, D. H. R. Vilkomerson, and K. F. Etzold, *SP453*, pp. 121-133 (Oct. 1976).

Key words: attenuation; breast tissue; broadband; high resolution; imaging; large aperture; pathology; pellicle; phase-contrast; transmission; ultrasound; velocity.

This paper describes methods for measurement of the ultrasonic attenuation and acoustic velocity of biological tissue. Initial results are given for a series of measurements on excised breast tissue that quantitatively demonstrate the correlation between ultrasonic attenuation and pathological state. A method for measuring changes in phase (due to velocity and thickness differences) in a wave as it passes through tissue, based on the phase-contrast technique, is described and demonstrated. The principal advantage of this method over other phase measurement techniques is that it is not as sensitive to the effects of structure overlying the region of interest.

Reflection techniques for measurement of attenuation and velocity, G. Kossoff, *SP453*, pp. 135-139 (Oct. 1976).

Key words: attenuation; breast; reflection techniques; ultrasound; velocity.

Pulse reflection techniques may be used for *in vivo* measurement of attenuation and velocity. Measurement of the two-dimensional distribution of pulse attenuat n may be obtained based on the equalization of internal echoes, while the differential pulse attenuation of encapsulated tissues is obtained by noting the difference in the echo from the posterior boundary at different frequencies. The average velocity in tissues may be measured by a simple technique if a reflector may be positioned at the posterior boundaries. A reflection technique for measurement of local values of velocity in heterogeneous tissues using two forward transducers separated by a known distance is suggested.

Ultrasonically-induced transient thermal gradients: Their potential role in acoustic parameter characterization of tissue, F. J. Fry, *SP453*, pp. 143-151 (Oct. 1976).

Key words: absorption; attenuation; impedance gradient; transient thermal gradients; ultrasonics; velocity.

Induction of transient thermal gradients by ultrasonic means with concurrent detection by ultrasound offers the possibility of determining quantitatively some of the acoustic properties of live tissue. The transient thermal gradient is related to the inherent acoustic absorption property of the tissue. When used appropriately, this gradient can be used to determine acoustic absorption, attenuation, velocity, and to enhance acoustic impedance differences at certain interfaces. Additional work beyond that reported here is needed to explore essential application of this method in the area of acoustic parameter determination which could lead to an enhanced tissue differentiating capability.

TAST: A non-invasive tissue analytic system, T. D. Sachs, P. T. Anderson, R. S. Grimes, S. J. Wright, Jr., and R. M. P. Donaghy, *SP453*, pp. 153-163 (Oct. 1976).

Key words: absorption; attenuation; brain; neoplasm; TAST; thermal effects; tissue; tumor; ultrasonic; velocity.

The Thermo-Acoustic Sensing Technique (TAST) uses two intersecting sound fields to measure the acoustic absorption of cerebral tissues at the point of intersection. A resolution of better than 1/8 inch was achieved in initial scans through the coronal plane of a fixed human brain. The sylvian and cortical fissures, basal ganglia, and ventricular boundaries appeared to be profiled by the TAST values. Conceivably, TAST may provide numerical tissue characteristics in 0.002 cubic inches of selected cerebral tissue. Should predictions based on current theory and data prove correct, TAST may become a repeatable noninvasive means of establishing intracerebral diagnosis.

Tissue characterization by ultrasonic frequency-dependent attenuation and scattering, P. P. Lele, A. B. Mansfield, A. I. Murphy, J. Namery, and N. Senapati, *SP453,* pp. 167-196 (Oct. 1976).

Key words: acoustic impedance; Bragg diffraction; computer processing; frequency-dependent attenuation; internal scattering; myocardial infarction; scattering; surface scattering; tissue characterization; ultrasonic spectroscopy; ultrasound diagnosis.

Studies conducted in this laboratory to explore the feasibility of utilizing acoustic impedance, attenuation, and scattering characteristics of tissues for enhancing the diagnostic capabilities of ultrasound are described. Frequency-dependent ultrasonic attenuation is found to be sufficiently greater in infarcted or otherwise necrotized tissues than in normal controls to permit their positive identification. Superficial and internal scattering properties of tissues hold the promise of being significant for diagnostic applications. The difficulties that will have to be overcome to successfully utilize these properties are discussed.

Frequency and angular dependence of ultrasonic scattering from tissue, C. R. Hill, *SP453,* pp. 197-206 (Oct. 1976).

Key words: Bragg diffraction; diagnosis; frequency dependence; orientation dependence; scattering; tissue characterization; ultrasound.

This paper reports on an ongoing program of work that, commencing in 1969, has been aimed at elucidating, and ultimately applying in clinical investigation, the processes by which ultrasound is scattered by volumes of human tissue. The report covers two related aspects of the work, concerned with the specific patterns of dependence of volume backscattering cross-sections on, respectively, acoustic frequency and the relative orientation between the axis of the interrogating ultrasonic beam and the backscattering structure. These two aspects of the subject have been treated from both theoretical and experimental points of view and both aspects show promise as possible bases for practical tissue characterization. Particular interest has centered in the orientation analysis approach, which constitutes an acoustic analog of Bragg diffraction of x-rays and has been shown to be capable of quantitatively significant differentiation between different human tissue types. The feasibility of applying this approach to *in vivo* tissue characterization has been demonstrated.

The scattering of ultrasound by red blood cells, K. K. Shung, R. A. Sigelmann, and J. M. Reid, *SP453,* pp. 207-212 (Oct. 1976).

Key words: angular dependence; blood; compressibility; density; distribution function; erythrocytes; hematocrit; scattering; ultrasound.

This paper reviews the experimental results obtained on the measurement of ultrasonic scattering properties of erythrocytes. The scattering is proportional to the fourth power of the frequency, as predicted by Rayleigh's scattering theory, for frequencies below 15 MHz. The scattering is not linearly dependent upon the hematocrit as would be expected for a single scattering process. Twersky's wave scattering theories are therefore applied to describe this result. The magnitudes of the monopole scattering due to compressibility and of the dipole scattering due to density are in good agreement with theory. Blood is the first tissue for which a nearly complete experimental and theoretical characterization of scattering exists.

Swept-frequency ultrasonic determination of tissue macrostructure, R. C. Waag, R. M. Lerner, and R. Gramiak, *SP453,* pp. 213-228 (Oct. 1976).

Key words: diffraction; Fourier transform; scattering; tissue characterization; ultrasound.

Ultrasound may be used to determine the acoustic structure of tissue on a scale corresponding to the wavelengths employed by using scattered signal to infer the organization of tissue elements. The underlying concept is the selective reinforcement or cancellation of certain frequencies depending on the relation of wavelength, reflector spacing, and orientation. A Fourier analysis of the received signal as a function of frequency or scattering angle reveals the acoustic variations corresponding to structure. By employing a swept-frequency ultrasonic signal, data similar to that obtained by angle scanning at a fixed frequency in x-ray diffraction has been obtained. Predicted deterministic interference patterns have been demonstrated for aluminum plates. Random scattering for two different sizes of dextran particles has also demonstrated predicted differences in scattering spectra. Pilot studies of liver specimens have shown marked variations in intensity-frequency distributions for individual disease processes.

Acoustic impedance profiling: An analytical and physical model study, A. C. Kak and F. J. Fry, *SP453,* pp. 231-251 (Oct. 1976).

Key words: attenuation; computer; deconvolution; impedance; impulse response; layer model; lucite; ultrasound.

Qualitative measurements of the acoustic impedance of tissue have been extensively exploited for medical diagnosis. In this paper, we report on an analytical and physical model study directed towards quantifying this parameter. The model selected is a medium having plane-parallel impedance interfaces which is insonified at normal incidence. Analytical expressions and computer algorithms are given for determining the impulse response of the medium and the impedance profile from this impulse response. Experimental data are presented which shows the accuracy with which the method can presently be applied.

Current problems in ultrasonic impediography, J. P. Jones, *SP453,* pp. 253-258 (Oct. 1976).

Key words: deconvolution; impedance profiling; impediography; impulse response; time-domain deconvolution.

The term impediography is used to describe a rather general class of signal processing operations which, when applied to pulse-echo ultrasonic signals, yield quantitative information concerning the physical properties of the system under study. The method uses deconvolution of acoustical impulses and their echoes to obtain the impulse response as a function of acoustical travel time. The integral

of the impulse response can then be analytically related to various physical parameters such as the specific acoustical impedance. This paper provides a general discussion of the problems associated with the practical implementation of impediography and outlines a number of important research areas which require additional study. Major problem areas discussed include: (1) corrections for nonplanar geometry, (2) development of accurate deconvolution algorithms, and (3) corrections and/or development of impediographic processing procedures for attenuation and scattering.

Tissue characterization by means of acoustic microscopy, L. W. Kessler, *SP453*, pp. 261-267 (Oct. 1976).

Key words: acoustic imaging; acoustic microscopy; attenuation; frequency dependence; impedance; microstructural analysis; tissue; ultrasound; velocity.

The complete characterization of tissue is extremely important for objectively identifying abnormalities and disease states. Optical methods of microscopy have been exploited to a great degree and now the electron microscope is being used in search of diagnostic clues at higher magnification levels. It is well appreciated, however, that these methods provide only limited access to the physical properties of tissue. Furthermore, the physical nature of an abnormality may prohibit its ever being revealed with visual observation techniques. Acoustic microscopy, on the other hand, can reveal new information, the structural elastic characteristics of viable tissue. Acoustic microscopy can also provide quantitative data on these tissue characteristics. As this additional information should have great diagnostic value, a general discussion of the methods and procedures employed is presented.

SP454. **An annotated bibliography of compiled thermodynamic data sources for biochemical and aqueous systems (1930 to 1975). Equilibrium, enthalpy, heat capacity, and entropy data,** G. T. Armstrong and R. N. Goldberg, *Nat. Bur. Stand. (U.S.), Spec. Publ. 454*, 67 pages (Sept. 1976) SD Catalog No. C13.10:454.

Key words: aqueous systems; bibliography; biochemical systems; enthalpy data; entropy data; equilibrium data; Gibbs energy data; heat capacity data; partial molal properties; thermochemistry; thermodynamics; review articles; water pollution.

Contained herein is a selected and annotated bibliography of sources of compiled and evaluated chemical thermodynamic data relevant to biochemical and aqueous systems. The principal thermodynamic properties considered herein are Gibbs energy and equilibrium data, enthalpies of formation and reaction, heat capacities and entropies, and the corresponding partial molal properties. Derived quantities used in calculating the above are also included. Transport and mechanical data have also been identified to a lesser degree. Included in the annotations to the data sources are brief descriptions of the types of properties tabulated, the classes of materials dealt with, and the degree of completeness of the compilations.

SP455. **Electrocatalysis on non-metallic surfaces.** Proceedings of a workshop held at the National Bureau of Standards, Gaithersburg, MD, Dec. 9-12, 1975, A. D. Franklin, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 455*, 372 pages (Nov. 1976) SD Catalog No. C13.10:455.

Key words: catalysis; characterization; chemisorption; electrocatalysis; electrochemistry; electrode processes; nonmetals; photoelectrolysis; solid electrolytes; surfaces.

This book presents the proceedings of a Workshop on Electrocatalysis on Non-metallic Surfaces, held at the National Bureau of Standards, Gaithersburg, Maryland, on December 9-12, 1975. The Workshop was sponsored by the Institute of Materials Research, NBS, the Division of Materials Research of the National Science Foundation, and the Division of Conservation Research and Technology of the Energy Research and Development Administration. The purpose of the Workshop was to review the most recent experimental and theoretical investigations on electrocatalysis on nonmetals and related topics, and to bring together electrochemists, surfaces scientists, and solid state physicists and chemists involved in research related to this topic. A total of 31 invited and contributed papers are here presented, together with a summary report of the final panel discussion. These proceedings are arranged to reflect, with some small exceptions, the program of the Workshop. The main groupings of papers are: I. Theory of Electrocatalysis and Related Topics; II. Characterization; III. Electrochemical Processes on Non-metallic Surfaces; and IV. Electrochemistry at Solid Electrolyte Interfaces. In addition, a final panel discussion (V) considered major problems, advances and opportunities revealed by the Workshop. *These proceedings include the following papers (indented):*

Electron transfer and electrocatalysis, H. Gerischer, *SP455*, pp. 1-19 (Nov. 1976).

Key words: chemisorption; electrocatalysis; electron transfer theory; multistep redox reactions; semiconductor surface states.

Non-catalyzed electron transfer is reasonably defined as an electron exchange between an electron donor or acceptor and an electrode under the condition of very weak interaction between the reactants and the electrode. The case of strong interaction between reactants and electrodes is analyzed with respect to its catalytic effect on electron transfer. It is pointed out that strong interaction may often inhibit electron transfer for a single electron transfer step at its individual equilibrium potential. Electrocatalysis is however found in multistep electron transfer reactions when the adsorption of intermediates in the reaction path brings the individual standard potentials of the single electron transfer steps closer to that of the overall redox potential. Examples for this effect of adsorptive interaction are given for metal and nonmetallic electrodes. It is further analyzed where the electron energy levels of the adsorbed reactants are located with respect to the characteristic energy levels in the metallic or nonmetallic electrodes and in the nonadsorbed species in solution. The important role of surface states at a nonmetallic electrode for chemisorption and electrocatalysis is emphasized.

Surface states, chemisorption and catalytic processes on transition metal oxides, T. Wolfram, F. J. Morin, and R. Hurst, *SP455*, pp. 21-52 (Nov. 1976).

Key words: catalysis; chemisorption; cluster states; electronic structure; energy bands; perovskites; surface states; transition metal oxides.

A discussion of the bulk and surface electronic states of transition metal oxides such as the perovskites is presented. The factors which determine the surface electronic structure are described and several examples of surface states and surface energy bands are presented using both cluster and energy band models.

The role of d-electron surface states in chemisorption and catalytic processes on transition metal oxides is considered. Several examples of surface reactions are given using a

cluster model for the substrate. These examples include the chemisorption of OH^- ions, the dissociative adsorption of H_2 and the hydrogenation of ethylene.

A detailed description of a Green's function theory for surface reactions is given in which both the reacting molecule and the solid are described by local basis states. The concept of the spectral weight function (local density of states) is used to describe delocalized bonding of molecules to a solid surface. As an example of the application of the theory the formation of localized electronic states associated with the adsorption of OH^- ions is considered.

Hartree-Fock calculations of hydrogen adsorption on nickel, copper, and magnesium oxide, A. B. Kunz, M. P. Guse, and R. J. Blint, *SP455*, pp. 53-58 (Nov. 1976).

Key words: adsorption; catalysis; copper hydride; magnesium oxide; molecular structure; nickel hydride.

The potential energy curves for NiH, HNiH, CuH, and HCuH resulting from the ground and first excited state atomic configurations are calculated using the unrestricted Hartree-Fock and generalized valence bond methods. NiH bonding in the $3d^84s^2$ configuration and CuH bonding in the $3d^94s^2$ configuration is by means of an sp hybrid orbital which comes from the $4s^2$ shell leaving a singly occupied orbital free to bond to another hydrogen atom. The bonding in the NiH$3d^94s$ and CuH$3d^{10}4s$ configurations is to the 4s orbital leaving in NiH a hole in the nickel 3d shell which interacts with another hydrogen only weakly and in CuH a closed 3d shell resulting in a repulsive potential energy curve. The interaction of hydrogen with a cluster representing a magnesium oxide surface V_I center was calculated using UHF. The lowest energy results when the Mg and O are singly ionized rather than doubly as in the bulk resulting in a surface radical. The hydrogen is bound over one of the oxygen atoms.

Stark model of the excitonic surface states observed on MgO[1], H. J. Zeiger, V. E. Henrich, and G. Dresselhaus, *SP455*, pp. 59-65 (Nov. 1976).

Key words: bulk excitons; electron loss spectroscopy; ionic crystals; Madelung potential; Mg^+; Mg^{2+}; MgO; Stark spectrum; surface excitons.

Using the energy and angle-of-incidence dependence of the electron energy loss spectra of MgO, we have separated the excitonic transitions from the Mg core levels to the excited states into those of bulk and surface origin. The bulk transitions are very nearly those of the free Mg^{2+} ion. The (100) surface-state transitions can be described by Stark-splitting of the energy levels of the surface Mg^{2+} ions in the intense Madelung electric fields at the crystal surface. The observations on other crystal faces of MgO and in amorphous MgO, however, suggest the possibility of the presence of surface Mg^+ ions.

Quantum chemistry and catalysis, R. P. Messmer and K. H. Johnson, *SP455*, pp. 67-86 (Nov. 1976).

Key words: catalysis; chemisorption theory; metal clusters; molecular orbitals; quantum chemistry; transition metal complexes.

A number of recent theoretical calculations on model systems relevant to chemisorption and catalysis is discussed. The approach taken is basically chemical in nature, emphasizing the local active site concept and employing a cluster of atoms to represent the substrate which interacts with the molecular or atomic adsorbate. The computational procedure used in these studies has been the self-consistent-field $X\alpha$ scattered wave (SCF-$X\alpha$-SW) method.

Relationship between electronic structure and catalytic behavior of transition metal carbides, D. R. Jennison, D. L. Klein, A. B. Kunz, K. M. Hall, and W. S. Williams, *SP455*, pp. 87-92 (Nov. 1976).

Key words: adsorption; catalysis; electronic structure; surface states; transition metal carbide.

We have studied the electronic structure of TiC within the unrestricted Hartree-Fock approximation. We find that strong covalent bonding occurs between the carbon 2s and 2p and the metal 3d orbitals. An absence of strong metal-metal bonding was noted. We tested various configurations on the metal atoms and found $4s^o3d^n$ energetically favored. Thus the formation of the carbon-metal bonds results in a loss of 4s character in the electronic structure. Cluster calculations confirm that the strength of the $\bar{b}$onds is sufficient to prevent the reestablishment of 4s character on a surface. The recent studies of Kunz, Guse, and Blint indicate that H bonds strongly to the 4s level, but not to the 3d. Although Ti metal can dissociate H_2, our results explain why the carbide apparently cannot. Similar results are anticipated on WC, suggesting a carbon deficient surface may have properties intermediary to W and WC.

The study of electrode surfaces by electrochemical methods, B. E. Conway and H. Angerstein-Kozlowska, *SP455*, pp. 107-124 (Nov. 1976).

Key words: atomic layers; chemisorption; cyclic-voltammetry; electrochemical adsorption; monolayers; surface processes.

Electrochemical methods for the study of surfaces are reviewed. Unlike high-vacuum techniques, they measure changes in the state of surfaces by virtue of occurrence of electrode surface processes, rather than giving information on the state of the surface itself. However, electrochemical procedures have high sensitivity down to 2 percent of a monolayer and multiple states of chemisorption can be distinguished with an energy resolution of 100-200 small calories. Interactions in the ad-layer can also be derived from the form of electrical transients. Combination of electrochemical methods with optical techniques, such as relative reflectivity and ellipsometry, provides a new dimension for studies in electrochemical surface science.

Electroreflectance study of the defect states in reduced n-type titanium dioxide, S. S. M. Lu, F. H. Pollak, and P. M. Raccah, *SP455*, pp. 125-131 (Nov. 1976).

Key words: defect states; *d*-electrons; electrolyte electroreflectance; surface states; titanium dioxide; transition-metal oxides.

We have investigated the electroreflectance spectrum of reduced n-type TiO_2, particularly below the fundamental absorption edge (~ 3 eV), in aqueous electrolyte, metal-semiconductor and metal-oxide-semiconductor configurations. We have observed for the first time in electroreflectance features in the spectrum for $\hbar\omega < 3$ eV which are related to the defect states. It is found that this structure is strongly dependent on the applied bias electric field. One optical peak appears at about 1.7 eV, an energy region in which structure has been observed in various other measurements which are related to both bulk (optical transmission, photoconductivity) and surface (electrochemical, electron loss spectroscopy) states. The intimate relationship

between the bulk defect levels introduced by reduction and surface states will be discussed. Our results will be interpreted in terms of a recent model of Morin and Wolfram for *d*-electron surface states in transition metal oxides.

Electron energy loss spectroscopy of surface states on titanium and vanadium oxides, V. E. Henrich, H. J. Zeiger, and G. Dresselhaus, *SP455,* pp. 133-138 (Nov. 1976).

Key words: adsorption; electron spectroscopy; ligand-field splitting; surface excitons; surface states; transition-metal oxides.

Using electron energy loss spectroscopy, we have studied the surface electronic structure of TiO_2, Ti_2O_3, $TiO_{0.87}$ and V_2O_3. A surface-state transition in the region of 1.5 to 2.5 eV is present in all of these materials when the surface is reduced by Ar-ion bombardment. Subsequent exposure of the surfaces to oxygen or water vapor reduces or completely eliminates this transition. The origin of the transition in terms of d-electron population of surface cations is discussed.

Dislocations in ZnO as channels for electron transfer from surface species, S. R. Morrison and T. Freund, *SP455,* pp. 139-148 (Nov. 1976).

Key words: dislocation; electrochemical; exchange current; semiconductor; traps; zinc oxide.

The results reported show that dislocations strongly affect the properties of the ZnO electrode and that with the help of electrochemical measurements a fairly complete picture of the electrical and chemical behavior of dislocations can be developed. It is shown that dislocations in ZnO act as hole or electron traps in the space charge region, as recombination centers, as points of electric breakdown under anodic polarization, and as current paths leading to exchange current even in an indifferent electrolyte. The dislocations can be passivated by annealing or by precipitation of impurities. A qualitative model is presented that can account for the observed effects of dislocations on the solid state and electrode properties.

Characterization of semiconductor electrodes in nonaqueous solvents, S. N. Frank, D. Laser, K. L. Hardee, and A. J. Bard, *SP455,* pp. 149-152 (Nov. 1976).

Key words: acetonitrile; cyclic voltammetry; electrochemistry; nonaqueous; semiconductor; silicon; titanium dioxide.

The large number of simple and reversible redox couples available in nonaqueous solvents allows convenient investigation of the band structures of semiconductors using electrochemical techniques. Comparisons of the cyclic voltammetric behavior of these couples at platinum and a semiconductor permits estimation of the relative energy levels of the conduction and valence bands and provides a means of mapping the gap region for intermediate levels and surface states. This technique is demonstrated with TiO_2 and n-type Si semiconductors. In spite of the large difference in band gaps between these semiconductors, their electrochemical behavior is similar and is ascribed to a similarity in the energies of their respective conduction bands and the energies of an intermediate energy level in TiO_2 and the valence band in Si.

Chemical theory of chemisorption and catalysis on the surfaces of non-metals, R. L. Burwell, Jr., *SP455,* pp. 155-166 (Nov. 1976).

Key words: catalytic hydrogenation; catalytic oxidation; chemisorption; cus; heterogeneous catalysis; surface coordinative unsaturation.

This paper surveys chemisorption and catalysis on nonmetals primarily from the point of view of localized, coordinatively unsaturated surface (cus) sites and with use of analogies to the chemistry of coordination and organometallic complexes. Topics covered include chemisorption on oxides of main group elements and of transition elements, heterogeneous catalytic hydrogenation and oxidation on oxides of transition elements, and chemisorption on group IV elements and group III-V compounds.

Electrocatalysis at transition metal oxide and carbide surfaces, P. Stonehart, *SP455,* pp. 167-174 (Nov. 1976).

Key words: electrocatalysis; heteropolyanions; phosphotungstate complex ions; "spillover" effect; transition metal carbides; transition metal oxides; tungsten bronze; tungsten carbide.

Due to the cost of noble metal electrocatalysts, significant research has been carried out to find nonnoble metal electrocatalytic materials. Transition metal oxides, usually doped tungsten oxides (bronzes), have been postulated previously due to their favorable electronic conductivity and stability in electrolytes. The surface chemistry of such electrocatalysts has been largely neglected but interesting parallels exist for the electron injection and extraction with heteropolyanions in solution. The heteropolyanions exhibit electrochemical properties of "bronze" crystals and can be considered to be microcrystallites. Optical studies show correlations between absorbance in the visible region and the electron density per transition metal atom. By and large, the transition metal oxide electrocatalysts have not yet fulfilled their expectations.

A related research direction has examined the activity of transition metal carbides for hydrogen oxidation in acid. Here it was found that tungsten carbide was the most active material but that it required a pretreatment. Surface studies established that the active form of the tungsten carbide electrocatalyst was slightly carbon deficient.

Adsorption and oxidation of bromide ion on tin oxide electrodes, H. Yoneyama and H. A. Laitinen, *SP455,* pp. 175-181 (Nov. 1976).

Key words: adsorption; anodic oxidation; electrocatalysis; semiconductor electrode; tin oxide electrode; transparent electrode.

Adsorption of bromide ion on a tin oxide electrode proceeded at such a slow rate that adsorption equilibrium took longer than two days to be reached. The electrode became active for oxidation of bromide ion depending on the extent of soaking in an acidic bromide solution. It was found that hydration of the electrode is an important factor to determine its activity for electro-oxidation of bromide ion. An electrode having a high activity lost its activity owing to surface oxidation upon polarization into the discharge potential region of bromide ion.

Cathodic pyrophosphate-lead dioxide electrode reaction properties, C. O. Huber, T. A. Berger, and R. E. Reim, *SP455,* pp. 183-189 (Nov. 1976).

Key words: amperometry; cyclic voltammetry; electrosorption; Langmuir; lead dioxide; pyrophosphate; Temkin; wax-bound electrode.

In the vicinity of +0.4 volts *vs.* S.C.E. in pH 8 solution pyrophosphate yields a cathodic current selective over orthophosphate at the lead dioxide electrode. Several aspects of this response were examined using α-electroplated lead dioxide on a platinum base and using mixed α-

β wax-bound lead dioxide electrodes prepared from the powdered material. Scanning electron microscope results indicated the topographical nature of the wax-bound electrodes. Current-voltage plots indicated an absence of a limiting current and relatively high residual currents as the potential becomes more cathodic. Scanning cyclic voltammetry suggested adsorption of reactive species. Capacitance and coulometric studies indicated clear evidence of adsorption and showed that the current was necessary to the desorption step. Current *vs.* concentration studies allowed fits to electrosorption models within certain concentration ranges. From these data estimates of some thermodynamic quantities were made. An electrode reaction process involving quasi equilibrium adsorption of the electron transfer product followed desorption of a plumbous-pyrophosphate complex is discussed.

Electrolysis by foreign metal monolayers, R. R. Adžić, A. R. Despić, D. N. Simić, and D. M. Dražić, *SP455,* pp. 191-200 (Nov. 1976).

Key words: electrocatalysis; foreign metal monolayers; Fe^{2+}/Fe^{3+} reaction; formic acid oxidation; oxygen reduction; underpotential deposition.

Catalytic effects of foreign metal monolayers deposited at underpotentials have been found in the case of Fe^{2+}/Fe^{3+} redox reaction on gold, oxygen reduction on gold, and oxidation of some small organic molecules on platinum. It was found that the catalytic effects of foreign metal monolayers originate in the change of surface electronic properties and the change of energy of adsorption of oxygen or oxygen-containing species for Fe^{2+}/Fe^{3+} and oxygen reduction respectively. In the case of formic acid oxidation foreign metal monolayers decrease the hydrogen adsorption on platinum thus preventing the formation of the main poisoning species.

Mechanisms of electrochemical reactions on non-metallic surfaces, E. Yeager, *SP455,* pp. 203-219 (Nov. 1976).

Key words: carbon; electrocatalysis; nickel oxide; oxide electrodes; oxygen electrochemistry; semiconductor electrodes.

Oxygen electrocatalysis has assumed new importance because of the involvement of the O_2 electrode in various fuel cells and electrolyzer systems. For O_2 electroreduction to proceed at reasonable current densities requires the adsorption of the O_2 molecule or ion on the electrode surface. Various models for the interaction of such O_2 species with surfaces and the corresponding pathways for the electroreduction are considered. Generally peroxide mechanisms are predominant in aqueous solutions on nonmetallic as well as metal surfaces but this leads to less favorable operating potentials for O_2 cathodes. A number of reasonably effective O_2 electroreduction catalysts have been identified for alkaline solutions but so far only high area platinum appears to combine reasonable activity and stability in acid electrolytes. Various electrocatalysts for which results have been reported in the literature are summarized. The electrochemical behavior of various carbons and graphites, lithiated NiO and various defect metal oxides including RuO_2/Ti is considered in some detail relative to O_2 generation as well as reduction kinetics.

Photoelectrolysis of water, J. G. Mavroides, D. I. Tchernev, J. A. Kafalas, and D. F. Kolesar, *SP455,* pp. 221-227 (Nov. 1976).

Key words: energy levels; photocatalytic electrodes; photoelectrolytic cells; photogalvanic cells; quantum efficiency; solar energy.

The photoelectrolysis of water has been investigated by experiments on cells consisting of an illuminated n-type semiconductor anode, an aqueous electrolyte, and a platinized-Pt cathode. It has been found that such cells operate either in the photogalvanic mode (no H_2 evolved) or in the photoelectrolytic mode (H_2 evolved at the cathode by decomposition of water), depending on whether or not the electrolyte surrounding the cathode contains dissolved oxygen. In both cases, current flows through the external circuit and O_2 is evolved at the anode. For operation in the photogalvanic mode, maximum values of 80-85 percent for the external quantum efficiency (η) for current production have been measured at $h\nu \approx 4$ eV with both single-crystal and polycrystalline TiO_2 anodes. Similar results have been obtained with $SrTiO_3$ anodes. The internal quantum efficiencies, corrected for reflection and absorption losses, are close to 100 percent, indicating that the band bending in both cases under photogalvanic conditions is sufficient to separate the electron-hole pairs generated by photon absorption and also that the oxygen overvoltage for charge transfer at the semiconductor-electrolyte interface is negligible for illuminated anodes. For operation in the photoelectrolytic mode, η is only 1-2 percent for TiO_2 and $\sim$ 10 percent for $SrTiO_3$ if the anode and cathode are shorted together, but the efficiency can be greatly increased by applying a bias voltage. All the observations, including the increased efficiency for $SrTiO_3$, can be given a straightforward explanation in terms of the energy levels of the electrodes and the electrolyte.

Electrochemical processes on strontium titanate electrodes, D. M. Tench and D. O. Raleigh, *SP455,* pp. 229-240 (Nov. 1976).

Key words: flat band potential; hydrogen evolution; oxide electrode; perovskite surface composition; rotating electrode voltammetry; semiconductor electrode.

The electrochemical properties of n-type single-crystal $SrTiO_3$ electrodes (10^{18}-10^{19} carriers/cm^3) were investigated in acidic sulfate solutions, with special attention to the hydrogen evolution reaction. AC impedance measurements, together with the voltammetric behavior of the ferro-ferricyanide couple and the onset of anodic photocurrent, established that the flat band potential, U_{fb}, lies about 250 mV cathodic to the reversible hydrogen electrode potential.

Slow-sweep cyclic voltammetry with a rotating electrode assembly established several hydrogen discharge mechanisms in moderately acidic solutions. Anodic to U_{fb}, chemical desorption ($H_{ads} + H_{ads} \rightarrow H_2$) appears to be rate limiting. At more cathodic potentials, electrochemical desorption ($H_3O^+ + e^- + H_{ads} \rightarrow H_2 + H_2O$) dominates. At still more cathodic potentials, where proton discharge becomes diffusion-limited, hydrogen discharge from H_2O appears to dominate. Anomalous current behavior at low pH values ($\sim$ 0.5) suggests possible proton diffusion into the electrode. ESCA measurements showed that the first few atomic layers of the $SrTiO_3$ surface, when brought in contact with aqueous solutions, become depleted in Sr.

Electrochemical activity of polymeric and monomeric iron phthalocyanines as a function of their spectral properties, A. J. Appleby and M. Savy, *SP455,* pp. 241-251 (Nov. 1976).

Key words: electrocatalysis; electronic structure; hydrogen peroxide; iron phthalocyanines; Mössbauer; optical spectra; oxygen; reaction mechanisms; ring-disk electrodes.

Samples of monomer and polymer iron phthalocyanines, prepared both in situ on carbon supports or in the form of thin films, using a gas-phase synthesis method, and by dissolution of liquid-phase preparations in sulfuric acid followed by reprecipitation on carbon, were examined by optical and Mössbauer spectroscopy. Their electrochemical activities for oxygen reduction were examined under steady-state conditions using the ultra-thin porous electrode technique, as a function of O_2 partial pressure, pH (11.8 – 16.4) and H_2O_2 additions. In addition, rotating ring-disk electrode experiments were conducted. Analysis of reaction orders and comparison of activities with those of the support have allowed the most probable mechanism to be determined, in which the rate-determining step is a chemical dissociation of the O-O bond. Correlations between electrochemical activities and spectral properties indicate the role of polymerization and of the spin configuration of the central iron atom in promoting catalysis. These effects result from reoxidation of $Fe^{II}iS$ to $Fe^{II}HS$ or iS, which is favorized by interaction between the polymer π electrons and the d electrons of the iron.

Electrocatalytic activity of phthalocyanines for oxygen reduction, R. J. Brodd, V. Z. Leger, R. F. Scarr, and A. Kozawa, *SP455*, pp. 253-258 (Nov. 1976).

Key words: ferric phthalocyanine; kinetics; oxygen reduction; phthalocyanine catalysts.

A survey of the activity of phthalocyanines as catalysts for oxygen reduction has identified several metal phthalocyanines with good activity. The central metal ion evidently controls the overall activity of the phthalocyanines for oxygen reduction. Ferric phthalocyanine had the best overall activity and approaches platinum in ability to catalyze the oxygen reduction reaction. The structure also influences the phthalocyanic activity. For copper as the central ion the order of activity is: polycopper phthalocyanine > copper phthalocyanine > copper porphyrazine. The substrate also influences the activity of the phthalocyanine as does solution composition. A mechanism for oxygen reduction is proposed which includes a hydrogen peroxide adsorption-desorption step. Rotating ring-disk results satisfactorily fit this model.

Continued growth of anodic oxide films at platinum and the mechanism and catalysis of oxygen evolution, A. Damjanovic, *SP455*, pp. 259-266 (Nov. 1976).

Key words: anodic films; dual barrier, electrocatalysis; oxygen evolution; platinum anodes; reaction mechanism.

It is shown on the example of oxygen evolution at platinum that thin anodic oxide films may profoundly affect kinetics and mechanism of an electrochemical reaction. At any potential above 1.OV an "insulating" oxide film grows over the electrode surface. The potential difference across the anode is then divided into the potential difference across the oxide film and that across the electrolyte double layer. The film is a barrier to electron transfer and together with the reaction across the double layer controls the kinetics and mechanism of the reaction. The exchange current density of the reaction decreases exponentially with thickness of the film. Only when the distribution of potential across the oxide film and double layer is taken into account, it is possible to explain the observed fractional reaction order with respect to activity of hydrogen ions and to propose a mechanism of the reaction that explains this reaction order. In the proposed mechanism a chemical step that follows first electrochemical step controls the rate in the double layer.

Electrochemical surface reactions on non-metals, R. Memming, *SP455*, pp. 267-280 (Nov. 1976).

Key words: anodic decomposition; cathodic decomposition; electrochemistry; inorganic bronze electrodes; metal electrodes; semiconductor electrodes; stability, surface layers; surface reactions.

Various surface reaction of semiconductors during electrochemical polarization are investigated which are of interest in connection with catalytic and photo-electrocatalytic processes. Examples for the anodic and cathodic decomposition are given and discussed with regard to the stability of electrode materials. In addition the formation of semiconducting layers on metal electrodes is described and their analysis and characterization investigated as far as electron transfer is concerned. Reactions at bronze electrodes leading to semiconducting surface films are included.

Oxygen evolution on semiconducting oxides, A. C. C. Tseung and S. Jasem, *SP455*, pp. 281-288 (Nov. 1976).

Key words: nickel cobalt oxides; oxygen evolution, Pourbaix diagram; semiconducting oxides; spinels; teflon bonded electrodes.

The oxygen evolution reaction is of particular interest to secondary metal air batteries and water electrolysis plants. However, most of the earlier work has been on precious metals and there are no guidelines for the choice of semiconducting oxides as oxygen evolving electrodes. In this study, the role of the metal/metal oxide or the lower metal oxide/higher metal oxide couple in determining the minimum voltage required for the evolution of oxygen is emphasized, together with other essential requirements such as electrical resistivity electrode microstructure, corrosion resistance and catalytic properties. A survey of various metal oxides based on the above criterion suggested that $NiCo_2O_4$ is of particular interest and teflon bonded electrodes based on this material gave over 13,000 A/m^2 at 1.63 V vs DHE, 70 °C, 5N KOH.

Mixed oxides as oxygen electrodes, G. Singh, M. H. Miles, and S. Srinivasan, *SP455*, pp. 289-296 (Nov. 1976).

Key words: electrocatalysis; nickel-cobalt oxide; nickel oxide; oxide electrodes; oxygen electrode reaction; ruthenium dioxide/titanium dioxide; spinel.

The irreversibility of the oxygen electrode reaction on metals and alloys is the main cause of efficiency losses in fuel cells, water electrolysis cells and some battery systems. Oxygen evolution always occurs on oxide covered surfaces while the reduction reaction generally takes place on bare metallic surfaces but can do so on oxides. Since the most likely candidates for reversible oxygen electrodes are oxides, mixed oxides or compound oxides, three types of oxides – NiO_x, $NiCo_2O_4$ and RuO_2ǀTiO_2 were examined as oxygen electrodes in KOH solution. When these oxide electrodes were prepared by thermal decomposition of their salts on a substrate, ratios of true to apparent surface areas of the electrodes were quite high (over 200) and the transfer coefficients, obtained from the Tafel lines for oxygen evolution in the temperature range 25-100 °C, were 1.5, as compared with about half that value on nickel electrodes. Above 100 °C $NiCo_2O_4$ and RuO_2ǀTiO_2 electrodes corroded in the strong (50%) KOH environment. Mixed oxides are more stable than simple oxides in the region of potential where oxygen reduction occurs. From the values of the Tafel slopes and exchange current densities for oxygen evolution and reduction $NiCo_2O_4$ (a spinel) and RuO_2ǀTiO_2, it is clear that

reversibility of this electrode reaction was not obtained. Other mixed oxides (including spinels and perovskites) will have to be investigated with the aim of developing reversible oxygen electrodes.

Surface and electrocatalytic properties of tungsten bronzes, M. F. Weber and H. R. Shanks, *SP455,* pp. 297-303 (Nov. 1976).

Key words: Auger electron spectroscopy; electrocatalyst; oxygen reduction; sodium depletion; Tafel plots; tungsten bronzes.

Tafel plots have been obtained for the oxygen reaction in acid solution on several alkali tungsten bronzes having different crystal structures. Platinum doped sodium tungsten bronze crystals were studied and the results compared with those of platinum free crystals of the same composition. In both cases sodium tungsten bronzes were found to be poor electrocatalysts for the cathodic reduction of oxygen. Similar results are reported for other alkali tungsten bronzes and for tungsten trioxide. Anodic treatment of the crystals affected the electrocatalytic activity of only the sodium tungsten bronze and the effect was a negative one. Cyclic voltammetry was employed to study the effects of the anodic treatment which created a sodium depletion layer on the sodium tungsten bronze surface. The existence and depth of the sodium depletion layer was determined by an Auger Electron Spectroscopy depth profile.

The electrochemistry of molybdenum oxides, J. Horkans, M. W. Shafer, and R. Peekema, *SP455,* pp. 305-312 (Nov. 1976).

Key words: electrochemistry; molybdenum oxides; orientation effects; oxygen reduction.

The general electrochemistry of four oxides of molybdenum, MoO_2, Mo_4O_{11}, Mo_8O_{23}, and Mo_9O_{26}, and the reduction of oxygen on these oxides, in 1 N H_2SO_4 have been investigated on natural faces of single crystals. These compounds are found to undergo electrochemical oxidation and reduction in the potential range between 0.13 and 0.73 V vs NHE. Oxygen does not influence the oxidation of MoO_2 and Mo_4O_{11}, but promotes the anodic dissolution of Mo_8O_{23} and Mo_9O_{26}. Oxygen reduction is supported on all these oxides at low currents and high overpotentials. Large effects of crystal orientation are observed. The chemical composition of the crystal has a much smaller effect. This is apparently due, at least in part, to a change of surface composition with changing electrode potentials. Thus, at a given potential, the composition of the surface layers of all samples may be similar.

Titanates as oxygen electrodes, U. Bertocci, M. I. Cohen, J. L. Mullen, and T. Negas, *SP455,* pp. 313-321 (Nov. 1976).

Key words: electrocatalyst; hydrogen evolution; lanthanum titanate; oxygen electrode; photo-assisted electrolysis; rutile.

Single crystal or polycrystalline compacts of five, TiO_2-based, oxide materials were investigated as oxygen electrodes. Potentiostatic and potentiodynamic measurements were accomplished at room temperature using neutral borate or 5M H_3PO_4 and inert (Ar) or oxygen environments. Observations of electrochemical behavior during illumination also were made.

Materials display slow, but continuous, changes in features of potentiodynamic scans, as well as changes in current with time at constant potential. Failure to attain steady-state conditions is attributed to specimen mechanical/chemical inhomogeneities and changes prior to and during measurement, variable surface conditions, together with electrode pre-treatment. For example, cathodic currents for O_2 reduction tend to increase after cathodic polarization, while H_2-evolution is hindered by dissolved O_2. Illumination increases the current density for O_2 reduction at very negative potentials while current decreases are apparent during H_2-evolution in Ar.

Results indicate that these oxides are not promising as electrocatalysts for O_2-reduction, although for a definitive assessment, well-defined and closely controlled surface conditions are necessary.

Ionic transport and electronic exchange at solid electrolyte interfaces, M. W. Breiter and G. C. Farrington, *SP455,* pp. 323-340 (Nov. 1976).

Key words: charge transfer processes; conduction mechanisms; interfacial phenomena; solid electrolyte.

Interest in highly conductive solid electrolytes, compounds that display conductivities comparable to aqueous electrolytes at room temperature, is great because of their many potential applications. This paper reviews conduction mechanisms and charge transfer at solid electrolytes having fast ionic transport. For the discussion, solid electrolytes have been grouped into stoichiometric compounds, doped compounds and nonstoichiometric compounds; interfaces are classified as two-phase and multi-phase boundaries.

Influence of water on beta alumina interfacial ion transport, G. C. Farrington, *SP455,* pp. 341-349 (Nov. 1976).

Key words: beta alumina; blocking electrode; interface; solid electrolyte; water.

Water, adsorbed on a beta alumina surface, significantly influences the nature of Na^+ ion transport across a nonaqueous electrolyte/beta alumina interface and the behavior of a Pt/beta alumina interface. Na^+ interfacial exchange current at 23 °C between beta alumina and propylene carbonate decreases with increasing surface hydration. Adsorbed water undergoes a number of faradaic reactions at a Pt/beta alumina interface, which otherwise should approximate an ideally polarizable or "blocking" electrode. This paper discusses the effects of adsorbed water on ion and electron transport at these two interfaces.

Overvoltage phenomena in solid-oxide electrolyte cells at elevated temperatures, W. L. Worrell, *SP455,* pp. 351-358 (Nov. 1976).

Key words: copper electrodes; interfacial resistance; metal-metal oxide electrodes; oxygen transport; steady-state overvoltages.

To develop a more quantitative understanding of the factors which establish overvoltages in solid-oxide electrolyte cells, constant currents have been passed through two types of symmetrical cells. At temperatures between 800 and 1000 °C, constant and reproducible cell overvoltages are obtained when the imposed current is less than 50 μA. The cell overvoltage (η) is directly proportional to the current (I), and the interfacial resistance, defined as equal to η/I, is constant for each cell at constant temperature. Assuming that oxygen concentration gradients in the metal portion of the electrodes establish the cell overvoltages, a quantitative expression has been derived to calculate the interfacial resistance for each cell. Reasonable agreement between calculated and experimental values of the interfacial resistance is obtained for cells having two-phase metal-metal oxide electrodes. This agreement indicates that oxygen is transferred between metal particles and the electrolyte rather than

through oxide particles in the electrodes. For cells with oxygen-saturated copper electrodes, the solubility-diffusivity product of oxygen in solid copper has been calculated from the overvoltage data.

SP456. **Measurements for the safe use of radiation.** Proceedings of an NBS 75th ANNIVERSARY Symposium held at the National Bureau of Standards, Gaithersburg, MD, Mar. 1-4, 1976, S. P. Fivozinsky, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 456,* 437 pages (Nov. 1976) SD Catalog No. C13.10:456.

Key words: calibrations; environment; measurements; medical; radiation; standards.

These proceedings are the compilation of papers presented at the Symposium, "Measurements for the Safe Use of Radiation," held in Gaithersburg, Maryland, March 1-4, 1976. The symposium addressed the present status and future requirements for measurements of ionizing and nonionizing radiation. Emphasis was placed on the needs for standardization and measurement assurance activities in medical, environmental, and personnel protection applications. *These proceedings include the following papers (indented):*

Historical development of the need for radiation protection and measurements in the United States, L. S. Taylor, *SP456,* pp. 5-11 (Nov. 1976).

Key words: radiation exposure; radiation measurement; radiation protection.

Early means of radiation measurement included photographic film, chemical compounds, selenium and ionization of air, and all were uncertain and inaccurate until about 1920. By 1930, ionization measurements between different laboratories and countries agreed within 2 or 3 percent. Also, quantitative limits for the exposure of radiation workers had been proposed and based on air ionization measurements—the roentgen. Accuracy requirements are ± 5 percent for radiation therapy but to maximize the benefits to patients greater attention must be given to measurement assurance or traceability. Accuracy for protection purposes will vary with the dose levels involved, for example, ± 10 percent at maximum permissible dose levels for radiation workers to perhaps ± 200 percent at the level of 10 mrems in a year for the population.

The standards laboratory and the radiation measurement system, R. S. Caswell, *SP456,* pp. 13-24 (Nov. 1976).

Key words: ionizing radiation; measurements; standards, uses of radiation.

In connection with a broad NBS study of the National Measurement System, the measurement system for ionizing radiation has been investigated. Eight classes of radiation users were considered: medical, nuclear power, industrial radiation processing, defense, environmental, science, chemical analysis, and miscellaneous radiation applications. System structure including regulators, standards laboratories, manufacturers, as well as final users of radiation was studied.

Several common threads were observed in these studies for the various classes of users: (1) While there is often a need for new NBS standards where no standards exist, where NBS standards do exist their accuracy is generally sufficient for present needs. (2) There is a great need for measurement assurance, especially where regulatory requirements are involved. (3) A need exists to help users with training, convenient laboratory standards, and handbooks for guidance. In other cases, new or augmented institutional structures within the system (e.g. secondary standards laboratories) are needed.

The federal regulatory agency and the radiation measurement system, R. H. Schneider, *SP456,* pp. 25-29 (Nov. 1976).

Key words: federal regulating agency; Food and Drug Administration; radiation measurements.

The official actions of a federal regulatory agency can have unique health and economic impacts. It is often not feasible for other parties to review the processes leading to such actions in detail and appeal is tedious and expensive. As a matter of equity it is incumbent on the agency to assure that the errors associated with facts on which actions are based are sufficiently small as not to affect the course of such actions. When radiation measurements are used as part of the factual basis for regulatory action this means that these measurements must be an integral part of the national radiation measurements system. The manner in which this has been achieved within the Food and Drug Administration as part of the implementation of the Radiation Control for Health and Safety Act of 1968, (P.L. 90-602) is described.

State responsibilities and the radiation measurement system, M. W. Parrott, *SP456,* pp. 31-36 (Nov. 1976).

Key words: abstract; compromise; ineffectiveness; measurements; radiation; regulations; states.

The states' radiation control programs have attempted to respond to public health need through a radiation measurement system that requires much more than instrument calibration. Few federal agencies can cover their responsibilities without state assistance. This paper explains these areas from one Radiation Control Director's point of view which may be shared by several others. Recommendations for some improvements are made.

Ionization chamber for absorbed-dose calibration, J. S. Pruitt and R. Loevinger, *SP456,* pp. 37-39 (Nov. 1976).

Key words: absorbed dose; calibration; cavity chamber; graphite chamber; ionization chamber.

A cavity ionization chamber has been constructed for in-phantom calibration in terms of absorbed dose. Its principle characteristics are the following: a smooth external shape, allowing insertion in the phantom without unnecessary air gaps; a large collecting electrode and a small internal air gap (1.3 mm), to meet Bragg-Gray cavity requirements; a uniform collecting potential gradient, allowing high potential gradients and low recombination loss; a guard electrode design which results in a stabilization time of a few seconds; construction of all three electrodes from pure graphite; and a day-to-day precision of about 0.1 percent. The chambers have been used to make the high-precision depth-dose measurements in water and graphite needed to transfer calorimetric absorbed-dose calibration in graphite to absorbed-dose calibration in water.

The development and application of monoenergetic x-ray sources, J. H. Sparrow and C. E. Dick, *SP456,* pp. 41-45 (Nov. 1976).

Key words: detector calibrations; fluorescence x-ray sources; K x-ray sources; pulsed x rays; radiographic imaging; steady-state x rays.

High flux standard x-ray beams have been developed in the energy range from 1- to 100-keV. These beams which are produced by direct excitation of characteristic x rays in

elemental targets are useful for the investigation of phenomena associated with radiological imaging and the calibration of radiation detectors. The design and performance of the sources and some applications to radiation measurement systems will be discussed.

The design of a mobile radiation calibration laboratory, R. C. Placious and J. C. Humphreys, *SP456,* pp. 47-51 (Nov. 1976).

Key words: mobile laboratory; radiation calibrations; radiation control; radiation measurement assurance; radiation standards.

A mobile x and γ-ray standards laboratory with facilities for calibration and testing of radiation instruments has been proposed as an effective method for propagating the national standards for exposure directly to state agencies responsible for local radiation control. NBS studies indicate that this can be accomplished by equipping a trailer truck with various sources of radiation, reference class instrumentation, and power generating equipment. The trailer described here incorporates radiation shielding which will be optimized in relation to beam collimation, direction, scattering, and maximum weight. The design provides all proper safeguards prescribed by federal or state agencies for transport over the nation's highways.

Automated calibration and recordkeeping system for x-ray survey instruments, T. R. Ohlhaber, F. J. Prevo, and T. L. Miller, *SP456,* pp. 53-57 (Nov. 1976).

Key words: automation; calibration; computer; recordkeeping; x ray.

A system for monitoring and controlling the calibration process for x-ray survey meters has been designed. A minicomputer with a real-time operating system and on-line disk storage provides the acquisition, reduction, and control parameters for the process and also maintains the recordkeeping for instruments dispersed over the country. The system is designed to rapidly provide information to multiple terminals about the calibration and availability status of survey instruments in order to facilitate the use of large numbers of instruments.

Standardization of a nationwide gamma radiation calibration system, E. F. Williams, Jr., P. V. Barrans, and G. H. Brodie, *SP456,* pp. 59-63 (Nov. 1976).

Key words: calibration; exposure rate; geometry; instrument; ion chamber; roentgen; standard; γ radiation; γ response.

A standardized γ radiation calibration system has been developed and is presently being used to provide uniform γ radiation fields for the calibration of ~ 500,000 γ measuring, civil defense survey instruments. The instrumentation, procedures, data handling techniques and secondary standards developed to make the system directly traceable to National Bureau of Standards are described and discussed. A simple test and evaluation of the total system is described. The test data obtained appears to show that the true roentgen is probably being provided to 48 maintenance locations with an accuracy of better than ± 6 percent and that the instruments can be calibrated to within ± 14 percent of the true exposure rate at one point on each detection range.

A reliable calibration program for ionizing radiation measurement, A. Jacobsen, *SP456,* pp. 65-69 (Nov. 1976).

Key words: calibration; dosimetry; ionization chamber; secondary standardization.

The recent availability in this country of the N.P.L. No. 2560 Secondary Standard instrument has afforded a new dimension to instrument calibration procedures. A description is presented of the accuracy, stability, and utility of the N.P.L. No. 2560 for calibration of various instruments to measure a wide range of ionizing radiation energies.

AIF-NBS radioactivity measurements assurance program for the radiopharmaceutical industry, R. Collé, *SP456,* pp. 71-76 (Nov. 1976).

Key words: assurance; measurement; radioactivity; radiopharmaceutical; standards; traceability.

The National Bureau of Standards supervises and administers on behalf of the Atomic Industrial Forum (AIF) a radioactivity measurements technology quality assurance program for the radiopharmaceutical industry. The program provides for a monthly distribution of both millicurie-and microcurie-level Standard Reference Materials to each of eight participating commercial radiopharmaceutical manufacturers. A number of the standards are distributed as "blind" samples to establish traceability to the national radioactivity measurements system. In addition to identifying measurement discrepancies, assistance is provided to the participants in eliminating the sources of difficulties, and in correcting errors in their measurement techniques. In this report, results for the "blind"-sample traceability exercises are given, and a discussion of identified sources of measurement errors and recommendations are also presented.

American National Standards Institute quality assurance program in radioactivity measurements, C. W. Seidel and J. M. R. Hutchinson, *SP456,* pp. 77-82 (Nov. 1976).

Key words: detectors; germanium; ion chamber; liquid scintillation; sodium iodide; standard.

The ongoing ANSI N42.2 program of writing procedural standards for radioactivity measurements with NaI(Tl) and Ge(Li) detectors, liquid scintillation counters and ionization chambers is described.

Filtered beams at the NBS reactor, R. B. Schwartz, I. G. Schroder, and E. D. McGarry, *SP456,* pp. 83-85 (Nov. 1976).

Key words: monoenergetic neutrons; neutron beams; neutron filters; neutrons; reactors; resonant scatterer.

Using a combination of resonant scatterers and filters, we are producing high intensity, very pure beams of 2 keV, 25 keV, and 144 keV neutrons at the NBS reactor. These beams have low background, are well calibrated and very stable, and are intended for use as calibration standards.

Neutron source calibrations at NBS for calibration checks of neutron radiation instruments, V. Spiegel, *SP456,* pp. 87-89 (Nov. 1976).

Key words: calibration; manganous sulfate; neutron source; radiation instruments.

The manganous sulfate bath method of neutron source calibrations at the NBS is described together with the corrections applied for neutron capture in the source itself, capture by competing nuclei of either fast or thermal neutrons, and thermal neutron leakage. The advantage of commercially available Am-Be (α,n) neutron sources as a calibration check for radiation instruments in the MeV range is stressed.

Ultrasonic measurements and calibration, H. F. Stewart, M. E. Haran, and B. A. Herman, *SP456,* pp. 91-97 (Nov. 1976).

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Key words: calibration; diagnostic ultrasound; ultrasonic measurements; ultrasonic techniques.

In the past few years ultrasound techniques have become well known and are receiving widespread acceptance in clinical practice. For example, diagnostic ultrasound is rapidly finding use as a compliment to other techniques and often is the modality of choice for visualization of structures within the body supplanting procedures involving the use of ionizing radiation. Some of the main areas of application at the present time are visualization of abdominal organs, pregnant uterus, and the heart. It is estimated that approximately 35 percent of the pregnant women in the United States currently undergo ultrasonic insonations and that by 1980 this number will increase to about 90 percent. Along with the increasing use of this modality come the responsibility for the assessment of the risk that may be involved with its use. This requires the measurement and characterization of ultrasonic fields by researchers engaged in the evaluation of biological effects associated with ultrasonic exposures. There is also the need to determine parameters of the ultrasonic field from fields produced by commercial ultrasonic devices in order to evaluate the potential risk their use may present on the basis of biological effects data. These measurements are especially necessary in view of the wide proliferation of such devices. In addition the establishment of any necessary performance criteria requires the quantification of the ultrasonic fields involved and calibration of measurement devices used.

Methods for the evaluation and calibration of microwave survey instruments, M. L. Swicord, H. I. Bassen, and W. A. Herman, *SP456*, pp. 99-105 (Nov. 1976).

Key words: microwave power density; microwave radiation measurement.

A facility has been established for the evaluation and calibration of microwave power density instrumentation. It includes an anechoic chamber with a precisely positionable cart for measuring gain and chamber standing waves. The operable frequency range is from 900 MHz to 10 GHz. A laser provides a means of aligning antennas. The absolute calibration of distance and microwave power are performed by NBS. The radiated electric field strength is then established by BRH as a primary standard using precise antenna gain measurement methods. An instrument evaluation facility includes an absorber-lined temperature chamber, a probe/slot-source positioning system, and devices for measuring the polarization response, modulation response, and the linearity of the microwave survey instruments.

NBS ultraviolet radiometric standards, W. R. Ott, *SP456*, pp. 107-110 (Nov. 1976).

Key words: detectors; NBS; radiometry; sources; standards; survey; ultraviolet.

A brief review of the standard sources and detectors available as services from NBS will be given. Emphasis will be on the use of such standards to calibrate the radiant power of unknown sources or the response of radiation detectors and spectral radiometers at wavelengths less than 400 nm. The following standards, listed in order of decreasing wavelength, are or will soon be available: the tungsten filament quartz-halogen lamp (above 250 nm); the tungsten strip lamp (above 225 nm); the low pressure mercury vapor lamp (253.7 nm); the deuterium arc lamp (165 to 350 nm); the argon "mini-arc" (115 to 400 nm); photodiode detectors (20 to 254 nm); and the synchrotron radiation source, SURF-II (5 to 400 nm). The relative strengths and limitations of these radiometric standards with respect to accuracy, reliability, convenience, and intensity and wavelength range will be discussed.

Quality assurance for measurements in therapy, R. J. Shalek, P. Kennedy, M. Stovall, J. H. Cundiff, W. F. Gagnon, W. Grant, III, and W. F. Hanson, *SP456*, pp. 111-118 (Nov. 1976).

Key words: medical physicist; radiation measurement; radiation therapy; tumor dose; quality control.

Recommendations regarding quality control in physics relating to radiation therapy are derived from experience with the Radiological Physics Center which is a national review program, and the Texas Regional Medical Physicists, which is a regional consultation activity.

Quality assurance measurements in diagnostic radiology, M. P. Siedband, *SP456*, pp. 119-130 (Nov. 1976).

Key words: diagnostic radiology; pass-fail tests; quality assurance measurements; x-ray quality control.

The concatenation of elements in an x-ray system necessitates a two level approach to system evaluation. The first level tests determine the weakest links of the chain while the second level tests provide more precise measures of elemental performance. Several types of first level pass-fail tests are described in terms of their utility in a routine quality assurance program for use in hospitals and in their relation to the second level tests. The requirements for accuracy and precision of the measurement apparatus are discussed.

Quality assurance for measurements in nuclear medicine, B. A. Rhodes, W. B. Hladik, and J. H. Gallagher, *SP456*, pp. 131-138 (Nov. 1976).

Key words: gamma camera; nuclear medicine; quality assurance; radiopharmaceuticals; ^{99m}Technetium.

This report reviews the measuring systems currently in use to assure safe and effective medical use of radioisotopes. One group of control tests measure the accuracy and precision of *in vitro* radiometric assays. Another group of measurements is applied to *in vivo* studies. This group includes measurements of quantity and quality of administered isotopes, performance of nuclear imaging devices and even the performance of physicians who interpret the images. Measures of overall system performance are also employed. The use of feedback loops to control and improve the quality of nuclear studies is an area of current exploration.

State and federal regulatory measurement responsibilities around medical facilities, L. H. Lanzl, *SP456*, pp. 139-146 (Nov. 1976).

Key words: diagnosis; measurement accuracy; medical facilities; regulatory; therapy; traceability.

Radiation exposure to man is due chiefly to diagnostic x-ray procedures, in which radiation is intentionally directed toward a patient. Radiation therapy presents a lesser problem because a smaller percentage of the population is subjected to such treatment. Recently, some innovative steps were taken in the State of Ill ois to reduce patient exposure in four diagnostic procedures without reducing the benefits derived therefrom. However, if these procedures are to be carried out properly, it is necessary to increase the precision and accuracy of radiation exposure measurements to the order of ± 2 percent. The usual accuracy and precision of radiation protection measurements are of the order of ± 20 percent. Thus, should the Illinois radiation protec-

tion rules become widely adopted, our national dosimetry network will need to upgrade exposure measurement techniques.

Nationwide evaluation of x-ray trends (next) program—And radiation measurements in the state, J. W. Shaver, *SP456*, pp. 147-152 (Nov. 1976).

Key words: diagnostic; nationwide evaluation; physician; technologist; x-ray departments; x-ray trends.

A Task Force of state and Bureau of Radiological Health representatives has applied the "standard man" concept as a method of evaluating the impact of government control efforts on medical x-ray exposure. Exposure data are collected using standardized procedures and equipment, and Organ Dose Index values are obtained for selected critical organs. It is expected that these data can be correlated with governmental agency radiological health activities.

Low level environmental radiation measurements with a plastic scintillation detector system, A. P. Hull and G. S. Levine, *SP456*, pp. 153-157 (Nov. 1976).

Key words: low level environmental radioactivity measurements scintillation detector.

A plastic scintillation detector-photomultiplier combination, operated in the current mode, has been developed at Brookhaven National Laboratory for the measurement of low level environmental radiation. Its output is digitized and processed by semiconductor circuits, which also provide for hourly compensation of variation in gain utilizing a built-in calibration source.

The instrument has been tested in the field for the past two years to establish its response capability to diurnal and longer term variation in background radiation, as well as small increments produced by a distant γ-field irradiation source. (Supported by U.S. ERDA.)

Precise environmental gamma-ray measurements utilizing standard Ge(Li) detectors, R. M. Keyser, G. V. Walford, and J. A. Cooper, *SP456*, pp. 159-167 (Nov. 1976).

Key words: environmental gamma-ray measurements; environmental samples; gamma-ray measurements; Ge(Li) detectors.

The analysis of environmental samples for radionuclides is fast becoming a large segment of the gamma-ray analyses performed. Many research laboratories and routine testing stations encounter a large number of samples. Some of these are relatively complex. In this paper we are concerned with the physical parameters of the measuring system; that is the characterization of the detector, the sample-detector relationship and the multichannel analyzer (analog to digital converter) and how these characteristics affect the accuracy of the measurement.

The counting sensitivity of a system can be used as a figure of merit for that system and can be defined as the minimum detectable limit or minimum acceptable limit. There are five factors affecting the sensitivity of a system. These are: the background, the system energy resolution, the detector efficiency and sample shape, the time allotted for the measurement, and the accuracy required for the result. We will discuss these parameters and their measurement and how they affect sensitivity for a series of standard germanium detectors.

The minimum-detectable-activity concept, J. C. Lochamy, *SP456*, pp. 169-172 (Nov. 1976).

Key words: background; critical level; detection limit; determination limit; less-than level; minimum detectable activity; statistical.

Various definitions of "minimum detectable activity (MDA)" are discussed and statistically valid representatives are presented. The methods of Currie are given primary emphasis and include development of the Critical Level, Detection Limit, Less-Than Level, and Determination Limit in terms of count-rate.

Use of NBS mixed-radionuclide gamma-ray standards for calibration of Ge(Li) detectors used in the assay of environmental radioactivity, B. M. Coursey, *SP456*, pp. 173-179 (Nov. 1976).

Key words: environment: gamma-ray measurements; Ge(Li) detectors; radioactivity; standards.

The NBS mixed-radionuclide gamma-ray emission-rate standards were first distributed in 1972 for use in calibrating Ge(Li) detectors used for measuring environmental radioactivity. These sources allow the user to prepare full-energy-peak efficiency vs. γ-ray energy curves for the detector from measurements made with a single standard. This paper will discuss the development of these standards and examine their current use in the assay of radioactivity in liquid, gaseous, and soil samples.

The safety and reliability of decentralized TLD, C. O. Widell, *SP456*, pp. 181-185 (Nov. 1976).

Key words: decentralized TLD; dosimeters; TLD reliability; TLD systems.

Decentralized reading of personnel TLD is in Sweden performed at the different nuclear power stations. The TLD results are automatically processed in the central dose register at Studsvik. In order to check and correct the readers, reference dosed dosimeters are used in each batch of TLD to be read. The reference dosed results are processed by the computer and will show the status of the different TLD readers. The reference dose irradiation is done with a Sr-90 source, which is placed above a rotating table in a brass shielding. The dosimeters are placed on this rotating table and will get a dose equivalent to 300 mrem gamma. In addition to this procedure a serie of calibration dosimeters is irradiated at a central calibration facility each month and read in the local TLD-reader.

Error analysis of environmental radiation measurements made with integrating detectors, G. de Planque Burke and T. F. Gesell, *SP456*, pp. 187-198 (Nov. 1976).

Key words: environmental radiation measurements; error; integrating detectors; TLD.

Proper use of integrating detectors (e.g., TLDs) for environmental monitoring, particularly around nuclear facilities, requires a high degree of measurement accuracy and a meticulous assessment of measurement errors.

Mathematical expressions for the dose in air at a site are formulated in terms of factors affecting the measurement including detector efficiency and calibration techniques as well as characteristics inherent to the detector such as energy dependence and contributions to the total during storage and transport of the detector. The assessment of errors for individual terms in the equations is discussed and errors are combined to determine the accuracy of the estimated dose.

Radio-frequency electromagnetic radiation from portable and mobile telecommunication transmitters, J. F. Thiel, *SP456*, pp. 199-202 (Nov. 1976).

Key words: antenna specifications; mobile telecommunication transmitters; RF radiation.

The increasing number of sources of electromagnetic radiation in the environment has placed more emphasis on the evaluation of such sources. Several of the more common sources of electromagnetic radiation to which individuals and equipment are exposed have been surveyed in an attempt to assess potential personnel hazards from the radiated fields. Measurements and examples of several typical types of antenna and transmitter combinations are presented.

An automated measurement system for determining environmental radiofrequency field intensities II, R. A. Tell, N. N. Hankin, J. C. Nelson, T. W. Athey, and D. E. Janes, Jr., *SP456,* pp. 203-213 (Nov. 1976).

Key words: antenna; microwave; minicomputer; radiofrequency; RF exposure; spectrum analyzer.

A measurement system is described which is used to measure environmental RF exposure levels. The system uses a spectrum analyzer interfaced to a minicomputer for data acquisition and is contained within a van for nationwide use. Special antenna systems allow isotropic field intensity measurements in selected bands between 0.5 MHz and 10 GHz.

The measurement of optical radiations: Selected practical considerations, R. W. Peterson, J. M. Coakley, K. Mohan, and R. James, *SP456,* pp. 215-221 (Nov. 1976).

Key words: calibrations; calorimeters; detectors; lasers; radiometry.

This paper describes the measurement capabilities for coherent and incoherent optical radiations at the Bureau of Radiological Health and discusses some problems that arise in developing a program of measurements required for enforcing compliance with Federal standards and for related regulatory responsibilities.

X-ray leakage from conventional and high voltage electron microscopes, D. F. Parsons, V. A. Phillips, and J. S. Lally, *SP456,* pp. 223-224 (Nov. 1976).

Key words: electron microscopes; health hazards; high voltage electron microscopes; x-ray leakage.

A survey of the x-ray leakages from the electron microscopes used by members of the Electron Microscopy Society of America has been carried out. Few, if any, out of several thousand long term microscope users received an exposure detrimental to health. However, a sufficient number of design errors, and accidental over exposures have occurred to make standardization of maximum allowed leakage desirable. The radiation hazards of high voltage electron microscopes are also discussed.

Intercomparison of personnel dosimeters, H. W. Dickson, W. F. Fox, and F. F. Haywood, *SP456,* pp. 225-232 (Nov. 1976).

Key words: dosimetry; gamma; intercomparison; neutron; personnel; reactor.

The first intercomparison of personnel monitoring dosimeters at Oak Ridge National Laboratory's DOSAR Facility was conducted during the period May 14-16, 1974. Ten independent laboratories and companies participated in an intercomparison of neutron and gamma-ray dosimeters used for routine personnel monitoring. The dosimeters, which were sent through the mail, were exposed at the Health Physics Research Reactor in three "standardized" radiation fields, which have been used for the past several years for intercomparing nuclear accident dosimeters. In addition, a 14-MeV neutron field was used as a fourth exposure condition. The results of the intercomparison show widely varying dose estimates; e.g., reported values of neutron dose equivalent have standard deviations ranging from 47-102 percent of the mean. A second intercomparison was conducted in a similar manner on February 18-19, 1976; however, only a few preliminary results are available at this time.

Environmental radiation measurements, J. E. McLaughlin, *SP456,* pp. 233-248 (Nov. 1976).

Key words: calibration; environmental gamma-rays; field testing; instruments; source distributions.

Determinations of radiation dose rates and radionuclide concentrations depend on systematic considerations of detector characteristics and instrument system calibrations, as well as the composition, source distributions, and flux-energy and angle distributions of the environmental radiation field. Routine *in situ* measurements around nuclear facilities are made primarily to monitor changes in certain radiation parameters. Even these measurements should be based on absolute determinations in order to attribute changes correctly to the source. The systematic considerations required for monitoring environmental sources are discussed and realistic examples of gamma-ray measurements are presented along with a suggestion for beta ray measurement.

Environmental measurements and regulatory responsibilities, J. M. Matuszek, *SP456,* pp. 249-261 (Nov. 1976).

Key words: environmental samples, laboratories; quality assurance; radioactive effluents; radioanalytical data; regulations.

During recent years, federal and state regulatory agencies have exhibited a propensity for issuing environmental radiation regulations regardless of the quality of the data base available for derivation of the standards. Particular examples of this trend are the AEC/NRC Regulatory Guide 4.3, EPA's Federal Safe Drinking Water Regulations, and some state and local edicts. Though the federal agencies appear to be improving in their efforts to obtain a sound environmental data base in certain areas, recent estimates of health effects attributable to ^{14}C effluents show that some interest continues for the "estimate and speculate" method of arriving at environmental radiation standards. Some state and local regulatory agencies, more closely attuned to political and media pressure, have rendered decisions or made statements which are not readily supported by the data obtained from environmental measurements. Environmental radiochemical laboratories, on the other hand, have found that quality assurance requirements ordinarily acceptable for routine surveillance programs are not always sufficient at low radioactivity levels for the regulatory needs developed. As even more stringent analytical requirements are imposed, the staffs of both the laboratories and the regulatory agencies must be fully cognizant of the statistical limitations of environmental data developed at very low radioactivity levels and respond accordingly in making regulatory decisions or setting environmental regulations.

Environmental radioactivity standards, A. N. Jarvis and D. G. Easterly, *SP456,* pp. 263-265 (Nov. 1976).

Key words: calibration; intercomparison studies; quality assurance; quality control; radioactivity; reference methods.

Policy decisions concerning environmental quality must be based on valid and comparable data. The distribution of

radioactive reference samples and conducting interlaboratory studies aids in the critical evaluation of such data and helps assure that measurements are correctly made, accurate, traceable to national radiation standards, and comparable. Standards distribution and intercomparison studies are discussed. Traceability studies between the National Bureau of Standards and the U.S. Environmental Protection Agency are reviewed. Identification and documentation of potential radioactive pollutants that could result from expanded energy programs are also discussed.

Personnel monitoring measurements, R. V. Griffith, *SP456,* pp. 267-276 (Nov. 1976).

Key words: betas; calibrations; dosimetry; gammas; neutrons; plutonium; x rays.

A personnel monitoring program must include a well integrated combination of dose determination methods, and should not depend on a single dosimetry system. Many of the necessary techniques have become well developed and dependable, such as the personnel gamma dosimeters in use today. However, other monitoring methods are still not adequate. The two most important personnel monitoring problems remaining are development of personnel neutron dosimeter and in-vivo measurement of plutonium at sublung burden levels. Although there are a few techniques under development to attack these problems, satisfactory long-term solutions will require much more work. As the developments in nuclear power and medicine continue, the need for solutions to these problems will intensify.

Personnel monitoring performance standards, B. H. Weiss, *SP456,* pp. 277-284 (Nov. 1976).

Key words: film badges, TLD, HPS working group; personnel dosimeters.

Efforts in the United States to provide some measure of uncertainty to the interpretation of routine personnel monitoring badge results have received the attention of various groups, individuals and governmental agencies for over 20 years. However, in general, health physicists and the users of these personnel monitoring devices still do not have great confidence in the results. This paper will review the history of the significant activities in trying to develop a system for testing the performance of personnel dosimetry services. This will also include a discussion of the current published standards and those in draft with respect to their different approaches and objectives. In particular, the paper will describe activities of the Nuclear Regulatory Commission in considering mandatory performance testing of personnel dosimetry and the work of a Health Physics Society Working Group which could be the basis for an NRC proposed rule.

Optical interferometric measurements of ultrasonic radiation and its applications to medicine, M. E. Haran and H. F. Stewart, *SP456,* pp. 285-297 (Nov. 1976).

Key words: optical interferometric measurements; ultrasonic medicine; ultrasonic radiation.

A modified Michelson interferometer is currently being used to map particle displacement amplitude within a beam of pulses ultrasound. One leg of the interferometer is raster scanned across a 4 micrometer thick, opaque gold coated membrane upon which the sound is incident. The reference leg of the interferometer has been modified to provide stability. Sensitivity has been found to be at least 10 picometers which corresponds to 1.0 micro watts/cm^2 at 1.5 MHz. Particle displacement amplitude is displayed in two modes: 1) displacement vs. position for each horizontal scan, 2) displacement vs. position for an entire frame by Z-axis modulation of a CRO. Frame rates of 2/sec. can be achieved. This system has been used to determine measured ultrasonic field patterns. Parameters of interest include peak intensity, intensity distribution, ratio of peak to average intensity and calculation of beam area. Methods for specifying beam areas will be discussed as well as the application of the system to evaluate medical diagnostic and therapy transducers. This system was developed by RCA Laboratories, Princeton, New Jersey.

Photon mass energy-absorption coefficient air/medium ratios for ionometric dosimetry 0.1 keV to 20 MeV, J. H. Hubbell, *SP456,* pp. 299-306 (Nov. 1976).

Key words: attenuation coefficient; cross section; dosimetry; energy-absorption coefficient; gamma-ray; photon; x ray.

The determination of photon absorbed dose in a medium by means of an air-ionization chamber depends in part on the ratio of the mass energy-absorption coefficient μ_{en}/ρ for air to that for the chamber wall material, to account for the differing atomic compostions. In this paper, mass attenuation coefficients μ/ρ developed at the National Bureau of Standards by the X-Ray and Ionizing Radiation Data Center from the latest theoretical cross section data are compared with measurements for selected low-Z elements of dosimetric interest. From this cross section data base, mass energy-absorption coefficients μ_{en}/ρ are derived for air and selected media, along with air/medium ratios, over the photon energ yrange 0.1 keV to 20 MeV including values at the cesium-137 and cobalt-60 energies. Comparisons are made with earlier published μ_{en}/ρ values and air/medium ratios.

Electron dosimetry with ionization chambers, M. J. Berger, S. M. Seltzer, S. R. Domen, and P. J. Lamperti, *SP456,* pp. 307-312 (Nov. 1976).

Key words: calorimeter; dose/ionization conversion; dosimetry; electrons; ionization chamber; stopping-power ratios.

This paper describes work at NBS dealing with the conversion of ionization measurements to absorbed-dose values in high-energy electron dosimetry. This work was done by two approaches: experimentally, through the comparison of calorimeter and ionization-chamber measurements in a graphite phantom, for incident-beam energies from 15 to 50 MeV; theoretically, via transport calculations of electron flux spectra and application of Bragg-Gray cavity theory, for beam energies from 1 to 60 MeV and for various media including water, tissue, graphite and plastics. The pertinent dose/ionization conversion factor has been determined with an estimated accuracy of 1 percent as a function of the beam energy and of the depth in the phantom. Experimental evidence has also been obtained on the influence of lead scattering foils on the value of the conversion factor.

Dose profiles in tissue and in air for therapeutic electron beams, G. Osman, *SP456,* pp. 313-326 (Nov. 1976).

Key words: dose profiles; electron dosimetry; pencil beam; therapeutic beam.

Electron dose profiles in body tissues and in air were obtained in this work theoretically and experimentally for 3 to 30 MeV incident beam energies. A knowledge of dose profiles in air is necessary for any extended SSD treatments or air gap beyond the end of collimator. Theoretical dose

profiles were predicted at various depths in tissue using the Osman's Model for therapeutic electron beams. Experiments were carried out with unfiltered beams in air and in tissue equivalent materials and results were compared with those predicted from our theoretical model. During the initial depth of penetration in muscle, fat, bone, lung and air, the electron dose profiles showed flat-top distributions within the geometrical configuration of the beam. At considerable depths in air or tissue (comparable to the range and field size), electron dose profiles have shown Gaussian distributions of various half-widths. Between the two extremes, electron dose distribution experiences a gradual transition from flat-top to the Gaussian. Slopes of these Gaussian curves varied inversely with the incident electron energy. The Gaussian dose distributions in tissues are generally not clinically acceptable. The flat distributions, however, can be obtained by proper design of scattering foils and electron cones. Tissue dose profiles as obtained from our model could provide useful input data for programming treatment planning with high energy electron beams, using mini-computers. It is expected that the predicted dose distribution by our model could also account for cone design and body-inhomogeneity.

Calorimetric dose measurements in fast neutron and cobalt-60 gamma-ray fields, J. C. McDonald, J. S. Laughlin, and L. J. Goodman, *SP456,* pp. 327-333 (Nov. 1976).

Key words: calorimeter; dosimetry; fast neutron; tissue equivalent.

A portable calorimeter, constructed of A-150 tissue equivalent (T.E.) plastic, was employed to measure dose in a cyclotron-produced fast neutron field and in a ^{60}Co gamma-ray field. The precision of these measurements ranged from $\pm$ 1-2 percent depending upon dose rate and signal to noise ratio. The absolute accuracy of measurements in the neutron field is estimated to be $\pm$ 5 percent and those in the ^{60}Co field to be $\pm$ 2 percent. A method for determining the magnitude of endothermic radiochemical effects which occur in T.E. plastic will be described along with other sources of uncertainty in calorimetric dosimetry.

Scattered radiation from a neutron collimator, F. H. Attix, L. S. August, and P. Shapiro, *SP456,* pp. 335-341 (Nov. 1976).

Key words: albedo; collimation; dosimetry; ion chambers; n-γ dosimetry; neutrons; scattering.

Fast-neutron beams are being employed in radiotherapy trials and associated radiobiology studies at numerous centers in the U.S., Europe, and Japan. Since collimated beams of various sizes and shapes are employed, it is desirable to know the composition of the scattered radiation component contributed by the collimator. A simple method is shown for deducing the field composition in terms of a 3-component model, from measurements made with three ionization chambers (tissue-equivalent, graphite, and magnesium). The dose contributed by the scattered radiation in the present example was found to be predominantly due to fast neutrons indistinguishable from those in the primary spectrum (from 35-MeV D^+ on Be). This method may prove useful for measurements in phantoms as well.

Dose control in radiation therapy, K. R. Kase, B. E. Bjarngard, B. J. Maddox, and G. K. Svensson, *SP456,* pp. 343-350 (Nov. 1976).

Key words: dosimetry; ion chamber; patient; precision; therapy; TLD.

Accurate and precise dose delivery is necessary in radiation therapy because of the steep tissue response-dose curve. This paper discusses the precision of dose measuring devices, therapy machines, patient dose delivery at the Joint Center for Radiation Therapy. Ion Chambers used for therapy machine calibrations show a precision of 0.7 to 1.3 percent while a thermoluminescent dosimetry (TLD) system shows a precision of 1.5 percent. Thereapy machines are calibrated on a weekly schedule and the variation in dose delivery between calibrations varies from 1 to 2 percent. Daily constancy checks on the linear accelerators using TLD show a variation of about 2 percent from day to day. Patient dose measurements using TLD at orthovoltage energies appear to have a precision of about 5 percent except for very small treatment fields where it is about 12 percent. Patient dosimetry at megavoltage x-ray energies shows a precision of 3.5 percent while at megavoltage electron energies it is about 5 percent.

Dosimetry procedures at the Northwest Medical Physics Center, D. Jones, D. Schumacher, and J. Washington, *SP456,* pp. 351-358 (Nov. 1976).

Key words: calibration; megavoltage radiotherapy; quality assurance.

The Northwest Medical Physics Center provides physics support to 28 radiotherapy institutions in the Northwest from a central location. The methods employed in on-site physical measurements, organization of data and long-term quality assurance are described.

Intercomparison of prescription dose delivery in the New England region, J. S. Blinick, J. Spira, D. Cail, and P. Plazeski, *SP456,* pp. 359-363 (Nov. 1976).

Key words: dosimetry; intercomparisons; radiation; supervoltage; therapy.

An intercomparison of radiation dosimetry among 16 institutions within the New England area was performed using a hand carried water phantom-ionization chamber system. Participants were asked to deliver 200 rads using their own beam data and computations to the chamber for each of eight field size and depth combinations. Average measured doses ranged from 200 to 204 rads. For all combinations, the standard deviation of the measured values was 3 percent.

Electron-therapy dosimetry, M. Ehrlich and P. J. Lamperti, *SP456,* pp. 365-370 (Nov. 1976).

Key words: dosimetry; electrons; impact; improvement; performance; radiation therapy; service.

A service for checking the dosimetry of electron beams in the energy range from 5 to 50 MeV was established in 1967, mainly for use by radiation-therapy departments. Since then, 34 radiation-therapy departments and several other groups have participated, a relatively large number of them only intermittently or for a total of only a few tests. There has been little improvement of overall performance over the years, less than one-half of the total number of irradiated dosimeters involved in any one test showing agreement to within 5 percent between the dose reported by the participants and the NBS dose interpretation, and up to one-quarter of the dosimeters showing disagreements of more than 10 percent. Only in a few exceptional cases was there an improvement in individual performance with continuing participation. It is concluded that means must be sought, in collaboration with the therapy community, to secure a more

favorable impact of this service on electron-therapy dosimetry.

Thyroid monitoring and minimizing I-125 uptake, M. M. Gabel, K. W. Price, and G. R. Holeman, *SP456,* pp. 371-379 (Nov. 1976).

Key words: bioassay; I-125 uptake; thyroid monitoring.

A method is described for the quantitative determination of I-125 uptake by the thyroid gland of all users of I-125. Causes for uptake are discussed and the need for monitoring is illustrated.

Attenuation phantoms for patient exposure measurement during radiographic examinations utilizing phototiming techniques, P. J. P. Lin, *SP456,* pp. 381-388 (Nov. 1976).

Key words: attenuation; exposure; phantoms; phototiming; radiographic examination; x-ray tube potential.

Aluminum phantoms have been obtained for patient simulation in radiographic procedures utilizing phototiming techniques. Thickness of these phantoms have been determined by (a) monitoring radiographic parameters of phototimed examinations and (b) attenuation measurements of x-rays in aluminum. Four of the eight selected radiographic procedures, namely (1) A-P cervical spine, (2) Lateral lumbar spine, (3) A-P abdomen, and (4) A-P skull examinations, have been subject to patient exposure limitation in the State of Illinois since January 1, 1975. Use of these aluminum phantoms in compliance testing and estimation of patient exposure are discussed.

Effects of measuring apparatus on x-ray attenuation measurements, T. J. Morgan, L. B. Smith, and Z. R. Hashmi, *SP456,* pp. 389-394 (Nov. 1976).

Key words: chamber energy response; geometry effects; half-value layer; photon attenuation.

Measurements of x-ray exposure are affected by the photon energy dependence of instrument response, and measurement geometry.

The effects of these factors on measured x-ray attenuation curves and estimates of first half-value layer in aluminum under certain test conditions are described, and estimates of the magnitudes of the effects are given.

A method for correcting half-value layer estimates obtained under less than ideal, but well-controlled, conditions is discussed.

kVp measurement for dental x-ray units, M. S. Moroz and J. A. Vukan, *SP456,* pp. 395-401 (Nov. 1976).

Key words: dental; kVp; x ray.

The kVp measurement of a sealed x-ray system using filtered radiation from a scatterer is discussed and compared to direct voltage measurement techniques.

National ionizing radiation standards, J. E. Leiss, *SP456,* pp. 403-416 (Nov. 1976).

Key words: ionizing radiation; measurement assurance; radiation users; standards.

Ionizing radiation in its many forms is used in an increasing number of ways to help solve important problems of our technological society. As these applications become more mature, the needs for reliable radiation measurement continue to increase, both to achieve the maximum benefit from the radiation use and also to assure that these applications are carried out safely. To meet these measurement needs, the National Bureau of Standards provides a wide variety of measurement standards and services. New standards are also being developed to meet a variety of new needs.

It is recognized that these radiation measurement standards by themselves are of limited usefulness unless they can be related to measurements made at the user level. Various mechanisms exist for this, including measurement calibrations, measurement traceability testing, and measurement assurance programs. The National Bureau of Standards carries out an increasing number of activities of this type. In some cases new or augmented institutional arrangements within the national measurement system for ionizing radiation appear necessary.

Non-ionizing electromagnetic radiation standardization, R. C. Baird and A. A. Sanders, *SP456,* pp. 417-425 (Nov. 1976).

Key words: calibrations; laser calorimeters; measurement assurance programs; non-ionizing EM radiation hazards; RF and microwave measurements; standards.

Calorimeters have been developed by NBS as accurate (± 1%) standards for calibrating laser power and energy measuring devices. A pilot measurement assurance program (MAP) is underway, with 12 industrial organizations participating. The anticipated accuracy is ± 5 percent. A formal MAP service will be announced about July 1976. Accurate standards for rf and microwave fields are not as well developed because of the inherently greater difficulty in measuring these fields caused by diffraction, interference, reactive fields, modulation, etc. NBS has developed accurate measurement and calibration techniques which will be fully implemented about August 1976 when a new anechoic (reflection-free) chamber will be completed. NBS is also developing stable transfer standards suitable for measurement assurance programs, and a pilot MAP with uncertainties of about ±0.5 dB (±12%) is anticipated during FY 1977.

SP457. **Building technology publications 1965-1975,** J. R. Debelius, S. G. Weber, and K. N. DeCorte, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 457,* 107 pages (Dec. 1976) SD Catalog No. C13.10:457.

Key words: abstracts; Center for Building Technology; key words; publications.

This report presents the National Bureau of Standard's (NBS) Center for Building Technology (CBT) publications of the past decade. Publications constitute a major end product of CBT's efforts. They appear in several publication series (Building Science Series, Technical Note, NBS Report, NBS Interagency Report, Handbook, Special Publication, the Journal of Research, and the Consumer Information Series).

SP459. **Performance evaluation of programmable robots and manipulators.** Report of a Workshop held at Annapolis, MD, Oct. 23-25, 1975, T. B. Sheridan, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 459,* 213 pages (Oct. 1976) SD Catalog No. C13.10:459.

Key words: guidelines; industrial robots; manipulator; performance evaluation; programmable robots; specifications.

The Workshop brought together representatives of industry, academic institutions and government agencies, including the potential designers, suppliers and users of a new generation of manipulators and robots which include varying degrees of control by both people and computers. The Conference was motivated by the lack of common bases for comparing one such device with another in terms of performance, or one task with another in terms of how well a given device will perform it.

The Workshop concluded that there is a need for (1) common definitions of many terms which now are the source of pervasive confusion, (2) common test codes, (3) checklists, guidelines, and specifications to help users and suppliers better communicate with one another, and (4) common tests for demonstration and exhibition of new research and development in this field. Conference participants emphasized that once these needs were met to allow communication in the field, actual performance testing should be left to the user and supplier in the free marketplace. *These proceedings include the following papers (indented):*

Evaluation of tools and tasks: Reflections on the problem of specifying robot/manipulator performance, T. B. Sheridan, *SP459,* pp. 27-37 (Oct. 1976).

Performance evaluation of manipulators from a kinematic viewpoint, B. Roth, *SP459,* pp. 39-61 (Oct. 1976).

Performance evaluation of ROMANSY from the viewpoints of mechanics and control, A. E. Kobrinski, *SP459,* pp. 63-68 (Oct. 1976).

Performance measurement and evaluation of general purpose manipulators, R. L. Paul, *SP459,* pp. 69-83 (Oct. 1976).

Manipulator system performance evaluation: Problems and approaches, N. L. Shields, Jr., T. B. Malone, and M. Kirkpatrick, *SP459,* pp. 83-90 (Oct. 1976).

Research on remote manipulation at NASA/AMES research center, W. L. Verplank, *SP459,* pp. 91-95 (Oct. 1976).

Experience and remarks on manipulator evaluation, J. Vertut, *SP459,* pp. 97-112 (Oct. 1976).

Performance evaluation of industrial robots, J. F. Engelberger, *SP459,* pp. 113-119 (Oct. 1976).

Robots for automated production of conventional ammunition, D. A. Morlock, *SP459,* pp. 121-122 (Oct. 1976).

Servicing of industrial robots—The modular concept, M. S. Konstantinov, *SP459,* pp. 123-129 (Oct. 1976).

A computer-aided robot operation systems design (Part 1), Y. Hasegawa, I. Masaki, and M. Iwasawa, *SP459,* pp. 131-139 (Oct. 1976).

Characteristics and evaluation of "Master-Slave Manipulators", D. G. Jelatis, *SP459,* pp. 141-146 (Oct. 1976).

Design and performance requirements for fuel recycle manipulation systems, J. G. Grundmann, *SP459,* pp. 147-154 (Oct. 1976).

Master slave manipulators and remote maintenance at the Oak Ridge National Laboratory, R. G. Jenness and C. D. Wicker, *SP459,* pp. 155-157 (Oct. 1976).

Performance evaluation studies at JPL for space manipulator systems, A. K. Bejczy, *SP459,* pp. 159-174 (Oct. 1976).

Performance measurement for undersea systems, A. J. Pesch and W. R. Bertsche, *SP459,* pp. 175-197 (Oct. 1976).

Contributions to forming criteria for the evaluation of robots and manipulators, M. Vukobratovic, *SP459,* pp. 197-203 (Oct. 1976).

SP460. **Use of Monte Carlo calculations in electron probe microanalysis and scanning electron microscopy.** Proceedings of a workshop held at the National Bureau of Standards, Gaithersburg, MD, Oct. 1-3, 1975, K. F. J. Heinrich, D. E. Newbury, and H. Yakowitz, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 460,* 169 pages (Feb. 1977) SD Catalog No. C13.10:460.

Key words: electron probe microanalysis; electron-solid interactions, magnetic domains; Monte Carlo electron trajectory calculations; particle analysis; scanning electron microscopy; thin film analysis.

This book is the formal report of the Workshop on the Use of Monte Carlo Calculations in Electron Probe Microanalysis and Scanning Electron Microscopy held at the National Bureau of Standards, October 1-3, 1975. The papers cover a wide range of topics within the field: the history and development of Monte Carlo methods for use in x-ray microanalysis; the study of the distribution of electron and x-ray signals by Monte Carlo techniques; the effect of the choice of scattering models on the calculations; techniques for considering the distribution of energies of the beam electrons propagating in the specimen; evaluation of ionization cross-section models; and applications of Monte Carlo techniques to the study of particles, thin films, and magnetic domain images. The contributions include reviews of general interest as well as papers treating specific topics. The volume should be of wide interest to workers in the fields of scanning electron microscopy, electron probe microanalysis, electron physics, and other fields involving the interaction of electrons with solids. *These proceedings include the following papers (indented):*

The history and development of Monte Carlo methods for use in x-ray microanalysis, H. E. Bishop, *SP460,* pp. 5-14 (Dec. 1976).

Key words: electron probe microanalysis; electron scattering; electron-specimen interactions; Monte Carlo electron trajectory calculations; scanning electron microscopy; x-ray microanalysis.

Green in 1963 first demonstrated the usefulness of Monte Carlo calculations to the understanding and development of the theory of x-ray microanalysis. As his calculations was based on experimental scattering data it was of relatively limited application. By 1965, at the 4th International Conference on X-Ray Optics and Microanalysis in Paris, papers from Japan and the United Kingdom demonstrated that a more general approach based on theoretical cross-sections was possible. Since then many further developments have been reported and a number of Fortran programs have become available.

Monte Carlo calculations may be divided conveniently into two classes; those aimed at a general understanding of the electron scattering process leading to x-ray production and those intended to solve particular problems. For conventional quantitative microprobe analysis of a flat specimen, uniform over the analyzed volume, the first class is the most important as it should lead to improvements in the conventional ZAF procedures. In a situation where there are special boundary conditions, such as thin surface films or particles, the second class is useful in predicting or interpreting the observed results. In this paper, the various approaches to Monte Carlo calculations are reviewed and their suitability for different applications is discussed.

Studies of the distribution of signals in the SEM/EPMA by Monte Carlo electron trajectory calculations—An outline, D. E. Newbury and H. Yakowitz, *SP460,* pp. 15-44 (Dec. 1976).

Key words: backscattered electrons; electron probe microanalysis; Monte Carlo electron trajectory simulation; scanning electron microscopy; secondary electrons; x rays.

Monte Carlo electron trajectory calculations provide a powerful technique for the study of the characteristics and distributions of the various signals generated in electron-specimen interactions. This paper is a review of the diverse applications of Monte Carlo techniques to the calculation of signal distributions. The following topics will be considered: extent of the primary interaction volume; lateral, depth, angular and energy distributions of backscattered and secondary electrons; the extent of the x-ray generation volume, and the depth distribution of characteristic and continuum x rays. Numerous examples of these calculated distributions are drawn from the literature and compared, when possible, with appropriate experimental results.

The effect of scattering models on the results of Monte Carlo calculations, L. Reimer and E. R. Krefting, *SP460,* pp. 45-60 (Dec. 1976).

Key words: electron microscopy; electron probe microanalysis; electron-specimen interactions; Monte Carlo electron trajectory simulation; scanning electron microscopy; x-ray generation.

A special Monte Carlo model is presented considered Mott scattering for scattering angles $\zeta > 10°$, a mean angular deviation caused by multiple scattering for $\zeta < 10°$, individual inelastic scattering events with energy loss $\Delta E >$ 200 eV and a continuous energy loss for $\Delta E < 200$ eV. Results of the Monte Carlo calculations are compared with experimental results of the backscattering coefficient, the angular and energy distribution of backscattered electrons and the transmission of thin films. Some calculations of the depth distribution of x-ray emission are reported. Parts of the program are changed to see which parts of the model influence the results.

Characteristics of a Monte Carlo program for microanalysis study of energy loss, J. Heńoc and F. Maurice, *SP460,* pp. 61-96 (Dec. 1976).

Key words: electron energy loss; Landau electron deceleration theory; microanalysis; Monte Carlo electron trajectory calculations; scanning electron microscopy; x-ray microanalysis.

The x-ray depth distribution curves obtained by the Monte Carlo method are in disagreement with the experiment. For this reason, Bishop proposed in his thesis the use of the theory of Landau, which takes into account the statistical nature of the energy loss of the electrons. This procedure gives a more realistic description of the events. We have taken into account, in this way, the effects of electron straggling upon the function $\phi(\rho Z)$ and the energy loss distribution of electrons passing through thin films. The general solution of the problem of electron trajectory simulation is straightforward, but it requires lengthy and expensive calculations. The procedure can be reduced in length by means of two simplifications, one of which was proposed by Bishop. Different treatments affect in different ways the statistical distributions of the variables which are being studied. In addition, the importance of the parameters and physical models which govern the diffusion of electrons (step length, diffusion model, screening parameter, etc.) will be discussed.

Evaluation of formulas for inner-shell ionization cross sections, C. J. Powell, *SP460,* pp. 97-104 (Dec. 1976).

Key words: cross sections; electron-probe microanalysis; electrons; inner-shell; ionization.

An evaluation is presented of various formulas that can be used to describe cross sections for inner-shell ionization by electron impact in the electron-probe microanalyzer. Owing to lack of experimental data, most of the discussion pertains to the case of K-shell ionization. For incident energies greater than four times threshold ($U_K > 4$), the Bethe equation can describe adequately the observed cross-sections and recommended values are given for the two Bethe parameters. For ($U_K < 4$), the classical result of Gryzinski or the expressions of Lotz or Fabre should be useful.

NBS Monte Carlo electron trajectory calculation program, R. L. Myklebust, D. E. Newbury, and H. Yakowitz, *SP460,* pp. 105-128 (Dec. 1976).

Key words: electron trajectories; magnetic effects; Monte Carlo calculations; multiple scattering x-ray generation; particle analysis; quantitative x-ray microanalysis; thin films; x-ray emission.

A number of Monte Carlo programs for obtaining information of interest to x-ray microanalysts and scanning electron microscopists have been developed; the outputs from many of these programs are discussed elsewhere in this volume. The purpose of this paper is to present the Monte Carlo program for microanalysis currently in use at the National Bureau of Standards. This program is a considerably extended treatment of the Curgenven-Duncumb formulation. A large number of electron trajectories can be simulated rapidly—about 1200 per minute of central processing unit time—at a reasonable cost. The electron scattering calculation is an approximation to multiple elastic electron scattering in an amorphous solid. Details of other assumptions made in constructing the program, as well as a number of comparisons of calculated and experimental data, are given in the text.

Application of Monte Carlo simulation to electron microprobe analysis of thin films on substrates, D. F. Kyser and K. Murata, *SP460,* pp. 129-138 (Dec. 1976).

Key words: electron probe microanalysis; Monte Carlo electron trajectory calculations; nuclear backscattering analysis; scanning electron microscopy; thin films; x-ray analysis.

A Monte Carlo simulation procedure has been developed for high-energy (1-50 keV) electron beam scattering, energy loss, and x-ray production in targets consisting of thin alloy films on thick substrates. The method utilizes experimental x-ray intensities referenced to thick standards, and avoids the problems associated with preparation and characterization of thin film standards. The chemical analysis C_i (weight percent) and mass thickness ρt (g/cm^2) of the alloy film can be deduced separately; specific examples are given of alloy films $Mn_xBi_{1\mp x}$ and $CO_xPt_{1\mp x}$ on SiO_2 substrates. The chemical analysis obtained with the Monte Carlo procedure is correlated with that obtained from nuclear backscattering energy analysis.

Monte Carlo-generated calibration curves of total electron backscatter yield η are presented for the case of Al films on Au substrates and Au films on Al substrates. These curves show a smooth transition of η versus ρt between the asymptotic limits of η(Al) and η(Au). The shape of the curve depends on the electron beam voltage E_0 (keV). Further experimental work is necessary to confirm the accuracy of these calculations for η, and then the method may be useful for a nondestructive, localized thickness measurement of thin films on substrates.

Calculation of type II magnetic contrast in the low-loss image in the scanning electron microscope, O. C. Wells, *SP460,* pp. 139-150 (Dec. 1976).

Key words: contrast calculations; energy filtering; low-loss electron image; magnetic contrast; Monte Carlo electron trajectory calculations; scanning electron microscopy.

The backscattered electrons which are often most useful in the scanning electron microscope (SEM) are those which have lost the least energy. (We have called these the "low-loss" electrons.) The question is whether they can be analyzed by a simple electron scattering model, or whether the Monte Carlo method must be used. Previously, it has been shown that a simple model based jointly on the Bethe energy loss law and a single Rutherford wide-angle scattering event can account for both the angular distribution and the absolute magnitude of the low-loss electron emission from amorphous SiO_2 with oblique incidence with an accuracy of a few percent provided that the energy loss is less than about 1 percent. This simple model has been extended to allow for curvature of the electron trajectories in the specimen, so as to calculate the contribution to Type II magnetic contrast in a suitable specimen caused by those backscattered electrons which have been scattered by a single wide-angle scattering event. Some preliminary theoretical results are given.

A study of type II magnetic domain contrast in the SEM by Monte Carlo electron trajectory simulation, D. E. Newbury, H. Yakowitz, and R. L. Myklebust, *SP460,* pp. 151-164 (Dec. 1976).

Key words: iron-silicon transformer steel; magnetic contrast; magnetic domain images; magnetic domains; Monte Carlo electron trajectory calculations; scanning electron microscope.

Magnetic contrast in the scanning electron microscope occurs by two distinct mechanisms: Type I magnetic contrast arises from the interaction of secondary electrons which have exited the specimen with leakage magnetic fields above the surface and Type II magnetic contrast arises from the interaction of beam electrons with the internal magnetic field. The observed properties of Types I and II magnetic contrast are reviewed. The proposed mechanism of Type II magnetic contrast, that of internal beam-magnetic field interactions, is modeled with the Monte Carlo electron trajectory technique. Details of the modifications to the standard Monte Carlo technique to account for magnetic deflection are given. Monte Carlo results are given for the following cases: contrast as a function of specimen magnetization, tilt, rotation, beam energy and energy fraction. The spatial resolution of domain edges is also considered. Calculated results are compared with experimental values, and the correspondence is excellent.

SP462. **Laser induced damage in optical materials: 1976.** Proceedings of a Symposium Sponsored by: National Bureau of Standards, American Society for Testing and Materials, Office of Naval Research, Energy Research and Development Administration, Defense Advanced Research Project Agency, July 13-15, 1976, NBS Boulder, CO, A. J. Glass and A. H. Guenther, Eds., *Nat. Bur. Stand. (U.S.), Spec. Publ. 462,* 410 pages (Dec. 1976) SD Catalog No. C13.10:462.

Key words: avalanche ionization; infrared windows; laser damage; metal mirrors; optical fabrication; optical materials; thin films.

The Eighth Annual Symposium on Optical Materials for High Power Lasers, the Boulder Damage Symposium, was hosted by the National Bureau of Standards in Boulder, Colorado, from July 13th to 15th. The Symposium was held under the auspices of ASTM Committee F-1, Subcommittee on Laser Standards, with the joint sponsorship of NBS, the Defense Advanced Research Project Agency, the Energy Research and Development Administration, and the Office of Naval Research.

About 160 scientists attended the Symposium, including representatives of the United Kingdom, France, Canada, and Brazil. The Symposium was divided into five half-day sessions, concerning Bulk Material Properties and Thermal Behavior, Mirrors and Surfaces, Thin Film Properties, Thin Film Damage, and Scaling Laws and Fundamental Mechanisms.

As in previous years, the emphasis of the papers presented at the Symposium was directed towards new frontiers and new developments. Particular emphasis was given to new materials for use at 10.6 μm in mirror substrates, windows, and coatings. New techniques in film deposition, and advanced in diamond turning of optics were described. The scaling of damage thresholds with pulse duration, focal area, and wavelength are discussed.

Alexander J. Glass of Lawrence Livermore Laboratory and Arthur H. Guenther of the Air Force Weapons Laboratory were Co-chairpersons of the Symposium. The Ninth Annual Symposium is scheduled for October 4-6, 1977, at the National Bureau of Standards, Boulder, Colorado. *These proceedings include the following papers (indented):*

Thermal distortion thresholds for optical trains handling high pulse powers, H. E. Bennett, *SP462,* pp. 11-24 (Dec. 1976).

Key words: laser windows and mirrors; optical figure; pulsed laser; thermal distortion.

The maximum pulse power level which components in the optical train of a high energy laser can pass is determined by the catastrophic damage threshold for the system. Before that level is reached, however, thermally induced optical distortion may make the beam unfocusable and hence for most practical purposes unusable. The amount of thermally induced optical distortion which may be tolerated depends strongly on the initial optical figures of the various components, and in the case of windows, on their optical homogeneity. Requirements for these parameters in a multicomponent infrared optical train can be surprisingly severe, and are frequently comparable to those commonly used for high quality optics designed for the visible region of the spectrum. Figure requirements for mirrors are more severe than for windows unless their index of refraction is above about 2.4. Adaptive optics may be used to remove some of the resultant wave front error, but the lower the requirements made by the optical train the more easily the adaptive optics system can correct for wave front distortions arising from the laser medium and from the optical path. A detailed analysis is required to set optimum tolerances for the various components in the optical path of a particular system. Simple relations can be developed, however, which can be used to predict the approximate pulse power handling capability of the optical train for short periods of time in terms of the material parameters of the various components in the system, their optical figures, and in the case of windows, their homogeneity. These relations can be used as figures of merit to select between materials and preliminary calculations for system design.

Electric fields and power dissipation in windows at oblique incidence, J. H. Apfel, *SP462,* pp. 25-28 (Dec. 1976).

Key words: electric fields; laser damage; oblique incidence; standing waves.

Formulas are provided for calculating the strength of the electric fields and the power dissipation due to weak absorption in a window illuminated by a collimated beam at nonnormal incidence. For a glass window the power dissipation per unit volume varies approximately as the cosine of the incident angle.

Analysis of laser-induced thermal stresses in laser windows, R. E. Rondeau and D. Ford, *SP462*, pp. 29-35 (Dec. 1976).

Key words: computer analysis; laser induced stresses; stress analysis; thermal analysis; zinc selenide window.

Laser induced damage in the ZnSe output coupler of a 15 kilowatt cw CO_2 coaxial electric discharge laser has been investigated. An analytical technique has been developed for predicting thermal stresses from in depth absorption of laser energy in laser window materials. A two-dimensional transient heat transfer code, APPLE, (Aerotherm Prediction Procedure for Laser Effects) was used to obtain the temperature histories of the irradiated window. The effect of window thickness, transmitted power level, absorptance and exposure time were investigated. The stress distribution in the circular disk was computed from radial and axial temperature distributions obtained from the APPLE code. This analytical technique has been used to determine maximum power levels and exposure times to prevent window damage in laser experiments.

Interferometric measurement of laser heated windows, E. Bernal and J. S. Loomis, *SP462*, pp. 36-44 (Dec. 1976).

Key words: interferometry; laser windows; optical materials; thermal distortion.

The optical aberrations in infrared window materials irradiated with a CO_2 laser have been measured at 0.6328 μm. The contributions of anisotropic aberrations due to polarization dependence were examined and found to be small for several materials of interest. Techniques for the semi-automatic digital analysis of our interferometric data will be discussed. The results will be applied to figure-of-merit characterization of window performance and calculation of far-field irradiance degradation.

Model calculations of the thermal profiles in irradiated windows and the resulting optical aberrations will be reviewed. Synthetic interferograms generated from these calculations were used to exhibit many of the experimentally observed features and to test the digital analysis techniques mentioned earlier.

New materials for chemical laser windows, J. A. Harrington, *SP462*, pp. 45-49 (Dec. 1976).

Key words: chemical lasers; infrared materials; laser windows; multiphonon absorption; optical absorption; water repellent coatings.

Many of the more common materials such as the alkaline earth fluorides, ZnSe, and the alkali halides have been studied for use as low loss windows on DF-HF chemical lasers yet there remain others which have received little or no attention at these wavelengths. We have begun to investigate some of these other materials in hopes of finding additional low absorbing materials which show potential as laser windows. Specifically, our measurements of the optical absorption in $LiYF_4$, Yttralox, ZnS, CdTe, KBr, SrF_2, and KRS-5 will be discussed and related to the intrinsic absorption in these hosts. In all cases, the measured absorption has been found to be greater than the intrinsic value. In addition to the absorption measurements on these substances, some recent optical absorption measurements on water repellent coatings on KCl will be discussed.

Studies of absorption in mid IR laser window materials, A. Hordvik, B. Bendow, H. G. Lipson, L. H. Skolnik, and R. N. Brown, *SP462*, pp. 50-57 (Dec. 1976).

Key words: bulk absorption; CO laser; HF laser; infrared laser window materials; multiphonon absorption; surface absorption.

An investigation has been made of the absorption properties of various potential laser window materials in the wavelength ranges of the CO_2, CO, and HF lasers. Various experimental techniques were utilized including emittance spectroscopy, Fourier spectroscopy, laser calorimetry, and a new photoacoustic technique which allowed both bulk and surface absorption to be determined simultaneously. The materials investigated were ZnSe, Al_2O_3, MgO, LiF, MgF_2, CaF_2, SrF_2, and BaF_2. At both the CO and HF laser wavelengths it was found that surface absorption was substantial in most cases and particularly so in the HF laser region. Among the materials tested, sapphire emerged as an excellent candidate for use with the HF laser provided its large surface absorption can be reduced substantially. Preliminary theoretical calculations have been made of the intrinsic absorption in ZnSe to interpret the measurements.

Effect of temperature and stress on the refractive index of window materials, A. Feldman, D. Horowitz, and R. M. Waxler, *SP462*, pp. 58-63 (Dec. 1976).

Key words: BaF_2; CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; thermal coefficient of refractive index; thermal expansion coefficient; ZnSe.

Windows subjected to high average power laser radiation experience a rise in temperature due to residual absorption. The temperature distribution, which is nonuniform, will distort the wavefront of the beam. The distortion results both from changes of refractive index with temperature and from changes of refractive index with stress induced by the temperature gradients. We are presently measuring dn/dT and the photoelastic constants of laser window materials at 632.8 nm, 1.15 μm, 3.39 μm, and 10.6 μm. Two new experimental arrangements have been constructed. The first permits measuring dn/dT and thermal expansion from -180 °C to $+200$ °C. The second is a highly stable and sensitive interferometer for measuring photoelastic constants in the visible, the near infrared, and the near ultraviolet. Thermal expansion data are obtained on CVD ZnSe, CaF_2 and BaF_2 between -100 °C and $+120$ °C and fitted to a third degree polynomial in temperature. We obtain dn/dT for CVD ZnSe at 632.8 nm over the same temperature range. The piezo-optic constants of fused silica and CVD ZnSe obtained with the new interferometer at 632.8 nm are in excellent agreement with values obtained by other methods.

Refractive index and temperature coefficient of refractive index of hot-forged calcium fluoride, M. J. Dodge, *SP462*, pp. 64-68 (Dec. 1976).

Key words: calcium fluoride; refractive index; temperature coefficient of refractive index.

The refractive index of a sample of hot-forged CaF_2 was measured from 0.25 μm to 8.0 μm by means of the minimum-deviation method on a precision spectrometer. Data were obtained near 21 °C and 34 °C. Each data set was fitted to a three-term Sellmeier-type dispersion equation, which permits interpolation of refractive index as a function of wavelength within a few parts in 10^{-5}. Using the index values obtained at the two temperatures, the change in index with temperature, $\Delta n/\Delta T(°C)^{-1}$ was calculated. The

refractive index and $\Delta n/\Delta T(°C)^{-1}$ values obtained for this specimen are compared with data previously published.

Fabrication and properties of laser window materials, R. M. Cannon, H. K. Bowen, A. M. Glaeser, H. J. Mayson, F. A. McClintock, W. M. Sherry, J. B. Vander Sande, and M. F. Yan, *SP462*, pp. 69-81 (Dec. 1976).

Key words: CaF_2; crack coalescence; flaw detection; flaw distribution; forging; grain boundary mobility; subgrains.

In hot forged CaF_2, as in forged alkali halides, fine subgrains develop and the subgrain size varies inversely with the forging stress. Dynamic recrystallization is more of a problem than for KCl or KBr; it results in very coarse grained regions in which the subgrains are poorly developed. In alkali halides aliovalent impurities exert a significant drag on grain boundaries causing large reductions in grain boundary migration rates and significant retardation of recrystallization and grain growth. Theoretical results for the boundary mobility and for the conditions under which a boundary may escape from the segregated impurity cloud are presented.

Theory of the macroscopic fracture behavior resulting from failure by coalescence of subcritical cracks shows the extent of detectable precracking and the effects of biaxial stresses, specimen size, and the distribution of microstrengths. The ultimate strengths do not fit an extreme value distribution even if the microscopic strengths do; this makes statistical design more difficult and may necessitate proof testing or inspection. Flaw strength distribution curves can be determined from acoustic emission measurements during microhardness testing. Crack openings as small as 0.1 μm have been nondestructively detected using scattered light. Better resolution is required for stronger materials for which crack openings as small as 0.01 μm must be detected.

Double-doped alkali halide laser windows, H. Posen, N. Klausutis, J. Bruce, J. A. Adamski, J. R. Weiner, and S. A. Kulin, *SP462*, pp. 82-86 (Dec. 1976).

Key words: double-doped KCl laser windows; grain boundary stability; hot forging; KCl; mechanical strength; microstructure; optical absorption; RbCl; $SrCl_2$.

We have observed grain boundary instability in alloys doped with 1.75 percent RbCl. Theoretical studies have indicated that doping with divalent ions can provide some strengthening, and at the same time provide grain boundary stability. In an attempt to provide both solid-solution strengthening and grain-boundary stability, we have studied a series of double-doped RAP-grown KCl crystals. The primary dopant is fixed at 1.75 mole percent RbCl, while the secondary dopant is varied from 10 ppm to 250 ppm $SrCl_2$. Polycrystalline discs were forged under constant strain rate. The strength, texture, 10.6 μm absorption, and grain-boundary stability were studied as a function of $SrCl_2$ dopant level. Our studies indicate that double doping with a divalent ion enhances grain-boundary stability without degrading other desirable window properties.

Intermediate temperature (0.5 to 0.7 T_{mp} K) forging of calcium fluoride crystals, R. H. Anderson, B. G. Koepke, and E. Bernal, *SP462*, pp. 87-94 (Dec. 1976).

Key words: annealing; fracture energy (γ_c); isostatic forging; kinking; microstructures; recrystallization temperature; veiling.

Crack free forgings have been successfully produced from CaF_2 crystals at temperatures as low as 0.5 T_{mp} (K) using an isostatic forging technique. Forging temperatures and isostatic pressures have ranged from 500° to 750 °C and to 28 MN/m^2 respectively. Most forging has been along ⟨111⟩ directions. The resulting microstructures varied from highly deformed structures with barely recognizable subgrains to structures with subgrain sizes of around 10 μm in crystals forged at higher temperatures. Annealing for long times at 720 °C resulted in recrystallization and a large grained polycrystalline structure. Internal cloudiness or "veiling" is observed in all ⟨111⟩ oriented forgings. The extent of the veiling decreases with increasing forging temperature. The fracture energies of several forgings are compared with the fracture energies of single crystals and large grained polycrystalline material.

Forging finished halide optical components, R. H. Anderson, E. Bernal, and R. J. Stokes, *SP462*, pp. 95-99 (Dec. 1976).

Key words: closed die; forging; isostatic; polishing; quartz; shaping.

The forging of completely finished halide optical components to eliminate the necessity of shaping and polishing is being evaluated. The forging operation is being done isostatically using a closed die technique. Quartz die faces are being used to produce the desired surface shape and finish. A synthetic oil is being used as the lubricant while the forging is performed at 275 °C.

To produce the finished component, two forging operations are being used. The first forging is necessary to produce uniform strain distribution. This pressing is then preshaped by water polishing before the final minor shaping operation.

These, as forged surfaces, appear superior to mechanically prepared surfaces for the deposition of the required protective and optical coating of thallium iodide.

Optical performance results obtained with these lenses will be compared with those obtained with conventionally polished halide and glass lenses.

Vapor deposition and mechanical properties of CdTe, H. L. Tuller, K. Uematsu, J. B. Vander Sande, E. L. Hall, and H. K. Bowen, *SP462*, pp. 100-118 (Dec. 1976).

Key words: cadmium telluride; growth kinetics; mechanical properties; microstructure; stoichiometry; transmission electron microscopy; vapor deposition.

The vapor deposition of CdTe from elemental cadmium and tellurium sources was studied as a function of the Cd/Te ratio, the supersaturation, and the substrate temperature. A multisubstrate arrangement was designed to enable simultaneous acquisition of growth data on six CdTe windows under conditions where substrate temperature and radial positioning remained the only variables. Polycrystalline blanks 4 $cm^2 \times 1$ mm thick were grown at rates of .02 − .10 mm/h with the growth rate exhibiting sensitivity to all of the above parameters. The affects of varying P_{Cd}/P_{Te_2} ratios during growth, as well as post growth annealing, on surface microstructure, grain size and void density, as observed under SEM and IR microscopy, will be presented.

Shear stress-shear strain results have been obtained from single crystal CdTe deformed in compression at 300 °C. The defect microstructures associated with this deformation schedule have been observed by transmission electron microscopy. The macroscopic mechanical behavior will be discussed in terms of the dislocation interactions observed for the various deformation states.

Absorbing tellurium inclusions in polycrystalline cadmium telluride: Estimates for extrinsic damage thresholds, H. S. Bennett and C. D. Cantrell, *SP462*, pp. 119-125 (Dec. 1976).

Key words: cadmium telluride; elastic compliance tensor; elastic moduli; extrinsic damage thresholds; high-power lasers; infrared materials; tensile stress.

Cubic cadmium telluride is a promising infrared material for highly transparent windows. However, one problem encountered in high-power laser systems is thermal extrinsic damage to the optical elements which arise from absorbing inclusions. Absorbing inclusions are impurities with physical and optical properties which differ substantially from those of the host material. Such inclusions may absorb an appreciable amount of the incident radiation and thereby may undergo thermal expansion. This produces major stresses within the host. In this paper, we give estimates of the maximum tensile stress as a function of inclusion size, laser pulse width, and laser power for polycrystalline Te spheres in polycrystalline CdTe. Our computations suggest that the heating of 0.1 μm to 10 μm aggregates of Te in CdTe when subjected to power densities of about 100 MW/cm^2 and pulse widths of about 200 ns may produce stresses comparable to or greater than the breaking strength of the CdTe host.

Hot-pressed $CdCr_2S_4$ for Faraday effect isolation at 10.6 μm: Preliminary damage tests, S. D. Jacobs and K. J. Teegarden, *SP462*, pp. 126-135 (Dec. 1976).

Key words: $CdCr_2S_4$; chalcogenide spinel; Faraday effect; ferromagnetic semiconductor; hot-pressed; infrared transmission; laser induced damage; optical isolation.

The ferromagnetic spinel, $CdCr_2S_4$ is considered an attractive candidate for future use in target back reflection isolation of high power infrared lasers for fusion investigations. Used with liquid nitrogen refrigerant in a Faraday rotator configuration, this material demonstrates isolation in excess of 30 dB and an insertion loss (due to material attenuation) of 30 percent in saturating magnetic fields of 3500 Oe. Minimal homogeneity requirements for dc magnetic field biasing and the scalability of the hot-pressing process make $CdCr_2S_4$ suitable for large aperture applications. Single crystal growth and hot-pressing procedures are currently being optimized to reduce extrinsic attenuation at 10.6 μm.

The threshold for laser induced damage in $CdCr_2S_4$ ($n_{10.6} = 2.84$) is of fundamental importance to the proposed application. Preliminary measurements have been made using a 50 ns, TEA CO_2 laser with a multimode output of 20 joules. The results indicate that this material has a damage threshold in excess of 2 J/cm^2.

Pulsed laser induced damage at the DF laser wavelength, M. Bass, K. M. Leung, C. Tang, and M. J. Soileau, *SP462*, pp. 136-144 (Dec. 1976).

Key words: alkali-halides; alkaline-earth fluorides; bulk damage; focal spot diameter; inclusion damage; interference ripples; pulsed DF laser damage; sapphire; scattering; waveform distortion.

A pulsed TE DF laser has been used to study the damage phenomenon in materials which are transparent to DF laser light (3.5 – 4.1 μm). We measured the bulk damage threshold in several alkaline-earth fluorides, alkali-halides, and sapphire. The peak on axis intensity which damaged CaF_2 and sapphire was 25 GW/cm^2. Surface damage occurred at intensities less than 1/10 that required for bulk damage. This was attributed to poor surface finish quality and points out the need for improvements in finishing optics for use with DF lasers.

Naval Weapons Center diamond turned optics facility, D. L. Decker and R. E. Cram, *SP462*, pp. 145-148 (Dec. 1976).

Key words: diamond single point turning; interferometric control; laser damage threshold; optical absorption; optical components; optical scattering.

The generation of optical surfaces by diamond single point turning or milling is of much current interest. This fabrication method can be cost effective and can readily produce very unconventional surfaces and components, allowing radically new system designs. In addition, this fabrication method can reliably produce optical components with superior characteristics including very low scatter, near intrinsic absorption and laser damage threshold. This paper will briefly describe the requirements and existing machines for diamond single point machining of high quality optics, and materials known to be amenable to this fabrication method. The characteristics of a new machine at NWC, which includes an air bearing spindle and carriage ways and closed loop interferometer control will also be discussed. The emphasis of the NWC effort is to explore selected areas of machine technology and to further explore the capabilities of diamond turned components.

10.6 μm pulsed laser damage studies of diamond turned KCl window surfaces, M. J. Soileau, J. M. Bennett, J. O. Porteus, W. Faith, J. Jernigan, and T. T. Saito, *SP462*, pp. 149-157 (Dec. 1976).

Key words: diamond turning; KCl laser windows; laser damage; 10.6 μm laser.

Laser damage measurements at 10.6 μm are presented for diamond turned surfaces of polycrystalline KCl. The two types of windows tested were hot-forged RbCl- and EuCl-doped KCl. Surface damage thresholds of the two materials range from 1.8 to 2.4 GW/cm^2. The optical properties of these specimens were measured after diamond turning and compared to chemically etched surfaces on the same specimens. RMS roughness, infrared scattering, and absorption at 10.6 μm were measured. The influence of the machining grooves on the character of the laser damage on the surface is discussed. The regularity of the surface defects produced by the diamond turning process offers a unique opportunity to study the effects of surface defects on the laser damage threshold of optical surfaces.

Surface, optical and laser damage characteristics of diamond-turned metal mirrors, D. L. Decker, M. J. Soileau, J. O. Porteus, and J. M. Bennett, *SP462*, pp. 158-164 (Dec. 1976).

Key words: Auger analysis; diamond-turned metal mirrors; laser damage; light scattering; optical absorption; surface roughness.

Diamond turning, in addition to its attractive manufacturing advantages, can produce superior optical components. Low scattered light, low absorption, and high damage threshold can be reliably realized with present technology. This paper intercompares the surface and optical characteristics of a large number of diamond-turned metal mirrors, including bare, electroplated, and sputtered substrates. Many diamond-turned specimens display near intrinsic pulsed laser damage threshold values, often accompanied by slip banding. This phenomenon has been previously observed only on atomically clean, well ordered single crystal surfaces of aluminum. In contrast, however, some electroplated specimens fail catastrophically by delamination. Regardless of sample type, most sites fail by melting initiated by localized absorbing centers.

Character of pulsed laser damage to Al at 10.6 μm inferred from single-crystal targets in vacuum, J. O. Porteus, M. J. Soileau, and C. W. Fountain, *SP462*, pp. 165-180 (Dec. 1976).

Key words: laser-induced stress; plastic deformation; single-crystal aluminum; slip bands; vaporization.

Pulsed laser-induced stress can produce permanent damage to metal surfaces, even in the absence of melting. Possible causes of such damage in Al are differential expansion resulting from thermal gradients and compression resulting from vaporization. By using single-crystal targets in which plastic deformation can be observed in the form of slip bands, one may obtain information on the direction, magnitude, and thus on the origin of stress. Targets having (111), (001), and (110) surface plane orientations were prepared and tested under oxide-free, ultrahigh vacuum conditions, using well-characterized 100 ns, 10.6 μm focused laser pulses. Vapor particle emission was monitored to provide an indication of vaporization pressure. At energy densities ≥ 37 J/cm^2 the results indicate the dominance of evaporative compression. At energy densities near and below the threshold for melting (14.2 J/cm^2) the interpretation of the observed slip banding is less clear, apparently due to the combined effects of thermal and evaporative stresses.

Laser-induced damage of mirror and window materials at 10.6 μm, R. Gibbs and R. M. Wood, *SP462*, pp. 181-188 (Dec. 1976).

Key words: dielectric coatings; infrared laser windows; laser heating of metal surfaces; laser mirrors; pulsed CO_2 laser damage; surface damage; 10.6 μm absorption; 10.6 μm optical components.

Pulsed laser-induced damage thresholds (CO_2 TEA laser, 60 ns FWHH) and 10.6 μm absorption measurements have been made on a wide variety of mirror and window materials. The effects due to different methods of substrate preparation and coating of metal mirrors have been studied, and as a result, mirrors of higher damage threshold have been manufactured. Front surface damage thresholds of uncoated windows have been measured and correlated with microscopically visible surface features. Improvement has been achieved by ion-beam etching of single-crystal materials. The damage threshold of dielectric coatings, both reflecting and antireflecting, has been found to be limited by microscopically visible coating defects.

Absorptance of dielectric enhanced mirrors at 5.3 μm, P. Kraatz, J. R. Buckmelter, and S. J. Holmes, *SP462*, pp. 189-194 (Dec. 1976).

Key words: absorptance; CO laser calorimetry; CO laser mirrors; dielectric-enhanced mirrors; infrared laser mirrors; metal mirrors; reflectance.

The absorptance of a variety of dielectric-enhanced mirrors has been measured in the 5.3 μm region using CO laser calorimetry. The samples comprise nineteen designs fabricated from ten dielectric material combinations deposited on thirteen basic mirror types (i.e., four substrate materials with a total of six metallic coating combinations). Thirty-two samples were fabricated by six vendors without duplications of any complete mirror design among any two (or more) vendors.

Results are grouped according to dielectric material combinations and design. Effects of substrate material selection and metallic coatings (if any) are discussed. The precision (i.e., standard deviation) of all absorptance measurements is presented. Accuracy, relative to (1-R) obtained from standard reflectometer measurements, is evaluated for selected mirrors.

Optical properties of mirrors prepared by ultraclean dc sputter deposition, P. A. Temple, D. K. Burge, and J. M. Bennett, *SP462*, pp. 195-202 (Dec. 1976).

Key words: aluminum; copper; flash desorption spectroscopy; gold; reflectance; silver; sputter deposition.

Sputter deposition is a method for producing mirror surfaces. However, the sputtering gas is generally incorporated in the metal film. This investigation was undertaken to determine the amount of gas trapped and the effect this gas had on film optical properties. Thin film mirrors of aluminum, silver, copper, and gold were prepared by dc sputter deposition under ultraclean conditions using argon or xenon as the sputtering gas. The sputtering gas entrapment was measured by a flash desorption technique. Film reflectance was correlated with preparation conditions and gas entrapment. In general, the film reflectance was reduced by the presence of sputtering gas. The gas trapped was a function of the metal being sputtered, the sputtering gas type, and the sputtering gas pressure. For example, the gas content of silver films could be varied over nearly two orders of magnitude. In some cases, films with reflectances as high as the best UHV evaporated films were prepared.

Materials for high-power window and mirror coatings and multilayer-dielectric reflectors, M. Sparks, *SP462*, pp. 203-213 (Dec. 1976).

Key words: attenuated total reflection spectroscopy; dielectric coatings; infrared lasers; laser damage; thin films.

Antireflection coatings and reflectors having lower values of absorptance than are presently available are needed for high-power, and even some low-power, applications. Intrinsic values of absorptance of antireflection coatings, multilayer-dielectric reflectors, and metallic-reflection-enhancing coatings are orders of magnitude lower than current experimental values A_{exp}. A major factor limiting the values of A_{exp} is that a given coating material usually has orders of magnitude greater absorption when deposited as a film than when grown as a bulk crystal. The most likely source of this extra film absorptance A_f is contamination of the film. Numerous contaminants include water, HCO_3, ClO_3, NO_3^-, OH^-, and CN^-. Contamination can occur before or during deposition, upon exposure to the atmosphere (where absorption by porous films and surface adsorption are important), or during use or storage. At 10.6 μm only two molecular layers of water or a packing density of 99.95 percent are formally required to give $A_f = 10^{-4}$, which is a typical desired value. High-packing-density films should be vacuum vapor deposited using ultraclean deposition conditions including thorough baking of the entire system, high-purity single-crystal starting materials, special care in evaporation, state-of-the-art substrate preparation, and ultrahigh vacuum. Spectroscopic and calorimetric measurements of $A_f(\omega)$ on very thick films and on normal-thickness films, both deposited on attenuated-total-reflection plates, should be made. Material-selection guidelines, including a *bulk* absorption coefficient less than 0.5 cm^{-1} and a value of the index of refraction in the required range, are developed and used to select the following 10.6 μm candidate materials: ThF_4, NaF, BaF_2, SrF_2, NaCl, KCl, $KGaF_4$, As_2S_3, As_2Se_3, ZnS, ZnSe, and TlI. Distinguishing absorption on the coating surface from that in the bulk of the coatings by utilizing the nearly zero electric field on the surface of certain coatings is proposed. Inclusion damage is expected at ~ 1-

10 J/cm² for nanosecond pulses or ~ 10 to several hundred J/cm² for microsecond pulses. Intrinsic damage is expected by heating at ~ 100 J/cm² for a 10 μs pulse and $A_f = 10^{-3}$, or by such nonlinear processes as electron-avalanche breakdown at ~ 10 J/cm² (i.e., I ≅ 10 GW per cm²) for a 10 ns pulse. Strongly absorbing 1-μm-radius inclusions spaced 175 μm apart in the coating give rise to absorptance $A_f \cong 10^{-4}$. Thermally induced stresses in a 2 mm-diameter detached film segment may be sufficient to cause additional detachment and a runaway process.

Alternate materials for infrared window coatings, A. D. Baer, T. M. Donovan, A. K. Green, and G. Turner, *SP462,* pp. 214-220 (Dec. 1976).

Key words: alkali halides; antireflectance coating; chalcogenide glasses; infrared optical properties; laser damage; optical absorption; optical scattering; thin-film coating.

The results from studies of a number of new materials (NaF, SrF_2 and As_2Se_3) to be used in antireflectance coatings for KCl and NaCl windows are reported. The preparation and measured properties of thin films of these materials are reported. The properties studied include absorption at 10.6 μm, scattering, structure, index of refraction, and damage threshold. NaF is a promising material in that it has a relatively low absorption and high damage threshold and can be used as a single-layer antireflectance coating on NaCl. The properties of NaF films are good enough that this material can be used as a component of 10.6 μm coatings. SrF_2 films are higher absorbing, but less easily damaged than BaF_2 films. As_2Se_3 films are more easily damaged than As_2S_3 films.

Design of three-layer antireflectance coatings, A. D. Baer, *SP462,* pp. 221-229 (Dec. 1976).

Key words: absorptance; antireflectance coating; bandwidth; coating design; multilayer coating.

Design constraints are less stringent for three-layer coatings than for two-layer coatings. Mathematical relationships which govern the design of three-layer antireflectance coatings are presented. These new relationships are analogous to those governing the design of two-layer coatings; however, a continuous range of solutions exists. Three-layer solutions are represented by closed curves in coating-thickness space, while two-layer solutions are represented by two discrete points. Armed with a knowledge of the performance of similar designs with similar materials, one can select the three-layer solution with lowest absorptance (within 10%). Three-layer coatings offer greater design flexibility than two-layer coatings not only because of the wider-range of solutions, but also because of a wider choice of viable materials. Three-layer antireflectance coatings can be formed entirely of low-index materials (BaF_2, NaF), or with the low index material next to the window (As_2S_3, NaF).

Characteristics of plasma polymerized ethane for laser window coating, T. A. Reis, H. Hiratsuka, A. T. Bell, and M. Shen, *SP462,* pp. 230-238 (Dec. 1976).

Key words: laser window coating; plasma polymerized.

Thin film coatings were produced by passing ethane through a radiofrequency glow discharge in a tubular plasma polymerization reactor. Infrared absorption characteristics of the plasma polymerized ethane (PPE) depends on the reactor conditions. Absorptions are large for C-H stretching (3.5 μm) and bending (7.0 μm) frequency regions. However, outside of these regions the absorptions are low. Under appropriate polymerization conditions, the absorption coefficient at 10.6 μm for PPE film on polished, finished KCl crystal is 4-7 cm^{-1}. The refractive index for PPE is 1.51 (at sodium D line), which is higher than that of KCl. Thus the use of multilayer coating for good antireflection is indicated. Moisture resistance was tested by exposing the coated crystals at room temperature and 84 percent relative humidity for 100 hours.

Epitaxy and optical scattering in TlI films, R. A. Skogman, *SP462,* pp. 239-245 (Dec. 1976).

Key words: biaxial birefringence; epitaxial microstructure; optical scattering.

Thallium iodide has been identified as a protective high index coating material for potassium chloride laser windows. TlI has a high refractive index and an optical absorption of less than 1 cm^{-1} at 10.6 μm. The protective quality of TlI lies in its insolubility and remarkable adhesion to potassium chloride. This adhesion is due, in part, to the epitaxial growth of TlI and KCl. TlI microstructures resulting from different epitaxial growth habits are responsible for the optical scattering observed in films grown on certain KCl orientations.

We have found that the alignment of the TlI b_0 axis parallel to the KCl ⟨110⟩ direction nearest the substrate surface determines the epitaxial growth habit. On the precise KCl (100) orientation, for example, *two* KCl ⟨110⟩ directions lie in the surface. This causes the TlI to nucleate in *two* orientations rotated 90° from one another. This unusual microstructure results in scattering by the diffraction of light passing from one biaxially birefringent orientation to another.

This model has been demonstrated for all KCl orientations and is well supported by x-ray data and polarized light microscopy. A practical solution to this problem has been found which routinely yields visibly clear TlI coatings.

Thin-film coating evaluation by attenuated total reflection, R. T. Holm and E. D. Palik, *SP462,* pp. 246-252 (Dec. 1976).

Key words: absorption; antireflection coatings; attenuated total reflection; laser windows; spectroscopic.

Attenuated total reflection (ATR) is a particularly attractive technique for the determination of absorption constants of thin-film coatings because a wide spectral range can be studied in a relatively simple way. Calculations of ATR spectra have been made for typical thin-film laser-window coatings, e.g., ZnSe on BaF_2 and ThF_4 on ZnSe. With the aid of such calculations, it is possible to establish the optimum ATR trapezoid geometry, angle of incidence, and film thickness for particular film-substrate configurations to maximize the sensitivity of the experiment to the absorption constant. ATR has potential applications in thin-film characterization for large-window coatings, as examination of an ATR sample coated at the same time would enable rapid quantitative evaluation of resulting coatings.

ZnSe sputtered coatings, D. A. Walsh and J. A. Detrio, *SP462,* pp. 253-263 (Dec. 1976).

Key words: absorption damage levels; coatings; CVD; hot pressed; sputtered.

The sputter deposition of ZnSe for laser window coating preparation has been studied using substrates of ZnSe and KCl. Sputtering targets made from CVD ZnSe and commercially hot pressed material were also compared. Self films of ZnSe and ZnSe were studied for absorption versus thickness using films of $\lambda/4$, $3\lambda/4$, and $5\lambda/4$ at 10.6 μm.

Calorimetric absorption measurements showed the HP target material produced coatings with 3 to 6 times greater absorption. Auger analysis indicated the presence of sulfur in the HP films, but none in films made with the CVD target. Both types of coatings appeared to be nonstoichiometric. Film and substrate inhomogeneity prevented reliable measurements of the film absorption coefficient. ZnSe on KCl coatings were investigated with Auger Spectroscopy in order to distinguish between target material effects and the influence of surface preparation methods. As-polished material showed Al and oxygen present at the interface which indicate a residue of polishing compound. The residue was readily removed by etching in concentrated HCl. Damage measurements were also made on the ZnSe coatings.

Laser damage studies of low index coating materials at 10.6 μm, M. J. Soileau, A. D. Baer, J. O. Porteus, J. L. Hernigan, W. N. Faith, T. M. Donovan, and A. K. Green, *SP462,* pp. 264-278 (Dec. 1976).

Key words: coatings; laser damage; laser windows; 10.6 μm lasers.

The 10.6 μm laser damage thresholds were measured for a variety of promising low index coating materials. Coatings deposited on KCl and NaCl windows were studied. Measurements on NaF, BaF_2, and SrF_2 indicate that all these materials have thresholds in excess of 1 GW/cm² when properly deposited. A comparison of the bulk and thin film threshold of these materials will be given. Our results indicate that NaF is an attractive alternative to ThF_4 since it has reasonably low absorption, a high damage threshold, and can be used as a single layer antireflection coating on NaCl. The primary mechanism of failure in the coatings tested was found to be coating delamination associated with defects on the substrate surfaces.

The use of rare earth fluorides as 10.6 μm antireflective coatings, A. Golubovic, J. Fitzgerald, I. Berman, J. Bruce, R. Bradbury, J. J. Comer, W. S. Ewing, and H. G. Lipson, *SP462,* pp. 27 -278 (Dec. 1976).

Key words: laser antireflective coatings; materials purification requirements; pulsed laser damage; rare earth fluorides; zinc selenide coatings.

The rare earth fluorides have been evaluated as possible antireflective laser window coatings at 10.6 μm. Emphasis was placed on SmF_3, EuF_3, and GdF_3 as a single layer coating for ZnSe and as the low index material in a 2-layer design with ZnSe on KCl substrates. The chemistry, structure and texture of the coatings were examined by several techniques including electron and optical microscopy, x-ray diffraction, Auger spectroscopy, and optical spectroscopy. Pulsed laser damage studies at 10.6 μm were performed to evaluate the relative merits of these coatings. As expected, the damage threshold for the single layer fluoride coatings as ZnSe were found to exceed the threshold of the 2-layer designs on KCl substrates.

Performance of $Ge_{0.45}Se_{0.55}/As_2S_3$ antireflection coatings at 3.8, 5.3, and 10.6 μm, J. F. Lewis and M. C. Ohmer, *SP462,* pp. 279-282 (Dec. 1976).

Key words: absorption; antireflection coatings; germanium selenide; infrared laser windows.

Transparent vitreous films of Ge_xSe_{1-x} have been grown by conventional evaporation techniques whose refractive index can be varied from 2.5 to 3.1 by varying x from .35 to .5. For x = .45 it is possible to construct a two-layer double-quarter wave AR coating where $Ge_{.45}Se_{.55}$ is the layer nearest the substrate and As_2S_3 is the outer layer. In a cooperative program, AR coatings of this type were synthesized at the Materials Research Laboratories, Victoria, Australia, and evaluated at the Air Force Materials Laboratory. AR coatings were deposited on Eu^{++} doped KCl (10.6 μm), BaF_2 (5.3 μm), and CaF_2 (3.8 μm). The coatings were characterized with regard to absorption, transmission, and bandwidth. For the KCl sample, the cw CO_2 damage threshold was determined. The absorption per surface for all wavelengths was less than .1 percent. Absorption bands at the shorter wavelengths were not visible in the spectrophotometer data.

AR-coated KCl damage at 10.6 μm, J. A. Detrio, R. D. Petty, M. C. Ohmer, and O. F. Swenson, *SP462,* pp. 283-291 (Dec. 1976).

Key words: alkali halides; antireflection coatings; coatings; KCl; laser damage.

Antireflection coatings on KCl windows for high power CO_2 lasers have been studied using focused radiation to establish relative damage thresholds. Single layer coatings composed of TlI, multilayer designs employing TlI and either KCl or ThF_4 were capable of withstanding 9 seconds irradiation at an average power density of nearly 130 kW cm^{-2}. Two definitions of the onset of mechanical damage were used; physical degradation including thermally induced fracture, and the first appearance of permanent residual strain as observed in a plane polariscope. Nomarski microscopic observations were also utilized to search for subtle signs of damage. Data were taken to detect any "conditioning" effects due to below-threshold irradiation. Conditioning was found to be negligible in all coatings studied except possibly one. No special handling precautions were taken and therefore these values represent the inclusion of ordinary laboratory environmental degradation. Correlations between damage levels and factors such as absorption were investigated.

Spectral dependence of damage resistance of refractory oxide optical coatings, B. E. Newnam and D. H. Gill, *SP462,* pp. 292-300 (Dec. 1976).

Key words: damage thresholds; electron avalanche; picosecond pulses; refractory oxides; standing-wave fields; thin films; two-photon absorption.

The laser damage thresholds of three refractory oxide material coatings (TiO_2, ZrO_2, and HfO_2) and SiO_2 were measured at three wavelengths (355, 532, and 1064 nm). For each wavelength, quarter-wave thick films were deposited on fused silica substrates by three manufacturers using electron-gun evaporation. Samples were irradiated with the primary, doubled and tripled frequency of a mode-locked Nd:YAG laser with pulse duration 20-30 ps. An increase of the threshold electric field from 1064 to 532 nm was measured, which was consistent with that predicted for electron-avalanche breakdown. Reduced thresholds at 355 nm indicated dominance of two-photon absorption.

The role of electric field strength in laser damage of dielectric multilayers, J. H. Apfel, J. S. Matteucci, B. E. Newnam, and D. H. Gill, *SP462,* pp. 301-309 (Dec. 1976).

Key words: dielectric films; electric fields; laser damage; optical coatings; standing-waves.

The intensity of the local electric field within a multilayer illuminated by a laser beam is determined by the vector addition of forward and reverse flowing waves as a result of in-

terference. The profile of the electric field intensity will therefore depend upon the multilayer design and can have a peak value which is more or less than the peak field of the incident beam. We have examined four multilayer designs, each composed of approximately equal numbers of high and low index films arranged so that the electric field profiles are significantly different. Laser damage thresholds for these coatings were compared with calculated electric field strength profiles.

For electron-gun evaporated titania/silica coatings damaged by 30 picosecond pulses of 1.064 μm radiation the damage threshold is dictated by electric field intensity in the titania layers.

Preparation techniques and hydroxyl concentration vs. surface damage threshold, R. A. House, J. R. Bettis, and A. H. Guenther, *SP462*, pp. 310-314 (Dec. 1976).

Key words: damage threshold; etching; flame polishing; fused silica; hydroxyl; ion polishing; polishing; roughness; surface damage; thin films; threshold.

A previous study on pulsed laser-induced damage on fused silica and other optical materials indicated that the damage threshold E (in V/cm) depended upon the RMS surface roughness σ (in A) as follows: $E\sqrt{\sigma} \sim$ const. Application of this relationship to previously measured thresholds affords a measure of the efficacies of various surface preparation techniques in improving surface damage thresholds, allowing a quantitative comparison. We have, in addition, observed an apparent correlation between thin film damage threshold and hydroxyl concentration in fused silica substrates. Depending on the particular film materials, the results imply that hydroxyl ions on the surface of silica substrates can be either beneficial or deleterious.

Laser induced damage to thin films immersed in liquids, A. Balbin-Villaverde and L. G. DeShazer, *SP462*, pp. 315-330 (Dec. 1976).

Key words: high power ruby laser damage; multilayer reflectors; single layer coatings; spark detection; thin films immersed in liquids.

A high power ruby laser system, operating in a single longitudinal and transverse mode was used to measure the damage threshold of a series of quarter-wave and half-wave single coatings, as well as for multilayer reflectors and antireflection "vee" coatings, immersed in different liquids: water, carbon disulfide, nitrobenzene, ethanol, methanol, acetone, and diiodomethane. Coatings of TiO_2, MgF_2, SiO_2, ZrO_2, and ZnS on substrates of glass were studied. Liquids were chosen covering a wide range of their physical properties. A correlation is intended between the damage threshold of the coatings and liquid properties. It is found that the damage threshold for all the films increases steadily with the low frequency dielectric constant of the liquids. For multilayer reflectors is also observed a clear dependence of the damage threshold on the liquid index of refraction, through the modification of the electric field inside the films.

Dielectric coatings on metal substrates, S. S. Glaros, P. Baker, and D. Milam, *SP462*, pp. 331-337 (Dec. 1976).

Key words: laser damage; laser fusion; metal mirrors; reflecting optics.

Large aperture, beryllium substrate based mirrors have been used to focus high intensity pulsed laser beams. Finished surfaces have high reflectivity, low wavefront distortion and high laser damage thresholds. This paper describes the development of a series of metallic coatings, surface finishing techniques and dielectric overcoatings to meet specified performance requirements. Beryllium substrates were coated with copper, diamond machined to within 5 microinches to final contour, nickel plated and abrasively figured to final contour. Bond strengths for several bonding processes will be presented. Dielectric overcoatings were deposited on finished multimetallic substrates to increase both reflectivity and the damage thresholds. Coatings were deposited using both high and low temperature processes which induce varying stresses in the finished coating substrate system. Data will be presented to show the evolution of wavefront distortion, reflectivity, and damage thresholds throughout the many steps involved in fabrication.

Spot size and pulse duration dependence of laser-induced damage, J. R. Bettis, R. A. House, and A. H. Guenther, *SP462*, pp. 338-345 (Dec. 1976).

Key words: frequency dependence; laser damage; spot size dependence; time dependence.

The threshold electric field for laser-induced damage in transparent dielectrics is shown to follow an inverse relation with the fourth root of the pulse duration. Preliminary analytical studies suggest the process involves the free-free plasma heating rate. The relationship is demonstrated for pulse durations ranging from a few picoseconds to several tens of nanoseconds. Furthermore, from considerations of total energy deposition, it is proposed that the threshold electric field follows an inverse relation with the square root of the damaging spot size. The results are compared to measured values with acceptable agreement.

Re-examination of laser induced breakdown in the alkali halides at 10.6 μm, C. C. Tang, K. M. Leung, and M. Bass, *SP462*, pp. 346-349 (Dec. 1976).

Key words: alkali halide crystals; laser induced damage; RAP grown materials.

Since the 10.6 μm bulk laser damage thresholds of alkali halides have been shown to depend on the experimental procedures used, we have remeasured the damage flux for these materials. Multiple shot per site thresholds were found to be higher than single shot per site thresholds for samples containing a large density of defects. By irradiating with two different spot sizes and observing an increase in damage threshold with decreasing spot size, a correlation between damage thresholds and the distribution of defects was determined. The single shot per site bulk breakdown electric field for NaCl using a 59 μm spot diameter was 1.8 MV/cm. Measurements made on conventional and RAP grown samples showed that both types of material preparation techniques are not yet able to produce samples with reproducible damage thresholds. Some, but not all, RAP grown samples are harder to damage than conventionally prepared materials.

Can a model which describes gas breakdown also describe laser damage to the bulk and surfaces of solid dielectrics, D. Milam, *SP462*, pp. 350-356 (Dec. 1976).

Key words: absorption; avalanche ionization; damage morphology; damage statistics; distribution of damage times; photoionization.

By assuming that laser-induced breakdown in highly transparent solids is a three-step process consisting of preionization, ionization growth, and absorption, it is possi-

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ble to explain "explosive" threshold damage, typical surface damage morphology, the presence or absence of damage statistics, and the distribution of breakdown times. Special constraints on the preionization stage necessary to explain these phenomena are discussed.

Laser damage to semiconductor materials from 10.6 μm CW CO_2 laser radiation, S. K. Gulati and W. W. Grannemann, *SP462*, pp. 357-364 (Dec. 1976).

Key words: carrier mobility; damping rates; laser damage of semiconductors; parametric plasma instability; photon induced excitation.

Damage thresholds for Si, Ge, GaAs, GaAsP, and GaP have been found experimentally. All the damage thresholds are of the order of KW/cm^2 for an irradiation time of 0.15 to 0.18 second. The damaged devices of Si and Ge show 30 to 50 percent decreases in carrier mobility at lower temperatures, thereby showing lattice damage. It is found that the experimental damage thresholds, surface and lattice damage can all be explained by applying the theory of parametric instability of the type formulated by DuBois and Goldman. The same theory is also applied to explain CW CO_2 damage thresholds for KCl windows as experimentally observed by Loomis and Huguly.

Phototransport damage of optical materials, S. M. Wong and D. L. Olson, *SP462*, pp. 365-370 (Dec. 1976).

Key words: absorption; electrotransport; ionic segregation; laser; momentum transfer; phototransport; scattering; vacancies.

Described as well-established electrotransport phenomena which may serve as analogies for studies of laser-induced damage in optical materials through phototransport. Phototransport or photomigration relates to the segregation of ionic species or in vacancies in the optical materials caused by a competitive momentum transfer from the scattered photons to the specific ionic species of the optical material. Such microstructural changes in the material are expected to cause severe increases in localized absorption and enhance laser-induced damage.

Resonant defect enhancement of the laser electric field, P. A. Temple and M. J. Soileau, *SP462*, pp. 371-378 (Dec. 1976).

Key words: damage theory; laser damage; 10.6 μm laser.

This paper describes a physical model for laser damage induced by surface defects. The model predicts that: (a) a polarizable defect will give rise to an electric field which can interfere with the laser field, (b) the interference pattern will be fixed in space along the direction of the laser beam polarization and with a spacing equal to the wavelength of the laser beam in the material, and (c) there is a strong defect size effect causing a significant increase in the field strength when the defect size is an odd number of half wavelengths. Experimental evidence supporting this model is presented.

3.8. APPLIED MATHEMATICS SERIES

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3.9 NATIONAL STANDARD REFERENCE DATA SERIES

Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS. Program under the authority of National Standard Data Act (Public Law 90-396).

NSRDS-NBS3, Section 7. **Selected tables of atomic spectra. A: Atomic energy levels—Second edition. B: Multiplet tables. O I,** C. E. Moore, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 3, Sec. 7,* 30 pages (Apr. 1976) SD Catalog No. C13.48:3/Sec. 7.

Key words: atomic energy levels, O I; atomic spectra, O I; multiplet table, O I; oxygen, first spectrum; spectrum O I; wavelengths, O I.

The present publication is the seventh Section of a series being prepared in response to the need for a current revision of two sets of the author's tables containing data on atomic spectra as derived from analyses of optical spectra. As in the previous Sections, Part A contains the atomic energy levels and Part B the multiplet tables. Section 7 presents this material for the first spectrum of oxygen, O I. The form of presentation is described in detail in the text to Section 1.

NSRDS-NBS57. **Yields of free ions formed in liquids by radiation,** A. O. Allen, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 57,* 25 pages (Apr. 1976) SD Catalog No. C13.48:57.

Key words: electrons; free ions; ion yields; liquid; nonpolar systems; radiation chemistry; radiation physics.

Free ions are those produced by ionizing radiation which escape initial recombination. Yields of free-ion pairs are tabulated for liquid alkanes, alkenes, alkynes, dienes and aromatic hydrocarbons, and other nonpolar and polar compounds, including alcohols, ethers, esters, halides, amines, nitriles, etc. Total ion yields for a few liquids are compared with gas phase ion yields. Theoretical treatments of these data are discussed.

NSRDS-NBS58. **Drift mobilities and conduction band energies of excess electrons in dielectric liquids,** A. O. Allen, *Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 58,* 23 pages (May 1976) SD Catalog No. C13.48:58.

Key words: conduction band; drift mobility; energy levels; excess electrons; hydrocarbons; ion mobility; liquids; mobility; quasifree electrons; solvated electrons.

The properties of electrons in liquids which are covered in this review include drift mobilities and the energy level (V_0) at the base of the conduction band. Tables are given of zero-field electron mobilities for several liquefied diatomic and inert gases, a number of aliphatic and aromatic hydrocarbons, and polar solvents. V_0 values are given for liquid helium and argon, a number of hydrocarbons, tetramethylsilane, and tetramethyltin. Theories attempting to explain these results are described in a qualitative way.

3.10. BUILDING SCIENCE SERIES

Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

BSS67. **Abnormal loading on buildings and progressive collapse. An annotated bibliography,** E. V. Leyendecker, J. E. Breen, N. F. Somes, and M. Swatta, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 67,* 60 pages (Jan. 1976) SD Catalog No. C13.29/2:67.

Key words: abnormal loading; alternate path; annotated bibliography; bibliography; building code; building regulations; collapse; failures; progressive collapse; specific resistance.

This bibliography on the subjects of abnormal loading and progressive collapse is an annotated listing of articles that have appeared in the technical literature from 1948 through 1973. The entries have been arranged chronologically by year and alphabetically within years. Both subject and author indexes have been included. The references listed have been selected as most representative of the historical background and best representing the origin and present state-of-the-art of current practice without undue repetition of data.

References pertaining to characteristics, frequencies, incidents, tests, design procedures, and regulations for many types of abnormal loadings are included. Among these are various types of accidental impacts, construction loads, explosions, faulty practices, and extreme atmospheric loads. Heavy emphasis was placed on referencing applicable building codes and regulations pertaining to the subjects of progressive collapse and abnormal loadings. This bibliography also contains numerous references to contemporary professional opinion as expressed in editorials and discussions of the subject and particularly, on the various regulations proposed. A large number of proposed analysis and design procedures, as well as applicable test results, are referenced. In addition to the general reference material, a careful search was made of the ten most recent years (1964-1973) of *Engineering News Record* to identify and annotate possible progressive collapse examples from building failures reported by that publication.

BSS69. **NBSLD, the computer program for heating and cooling loads in buildings,** T. Kusuda, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 69,* 398 pages (July 1976) SD Catalog No. C13.29/2:69.

Key words: ASHRAE task group on energy requirements; conduction transfer functions; heating and cooling load; National Bureau of Standards heating and cooling load computer program.

A comprehensive computer program called NBSLD, the National Bureau of Standards Load Determination program, has been developed at NBS to reflect the time change of the many building parameters which are pertinent to accurate estimation of energy usage for heating and cooling. Current status of heating and cooling load techniques is reviewed. Of general interest are unique features of NBSLD which are not available in existing computer programs. A summary of various subroutines of NBSLD is given along with the detailed procedures for them. These subroutines constitute the recommended subroutine algorithms of the ASHRAE Task Group on Energy Requirements. Complete Fortran listing of NBSLD and data preparation forms are given for those who wish to use the program. The NBSLD computation is on the basis of the detailed solution of simultaneous heat balance equations at all the interior surfaces of a room or space. Transient heat conduction through exterior walls and the interior structures is handled by using conduction transfer functions. The use of heat balance equations, although time-consuming in calculation, can avoid the vagueness and uncertainties inherent in the more popularly used weighting factor approach. In addition, it is more accurate for a specific building design.

BSS73. **Structural performance of masonry walls under compression and flexure,** S. G. Fattal and L. E. Cattaneo, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 73,* 65 pages (June 1976) SD Catalog No. C13.29/2:73.

Key words: brick; buckling; composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls.

Ninety-five prisms and fifty-six walls of brick, concrete block and composite brick and block masonry construction were tested under various combinations of compressive and transverse loads. Constitutive relations for masonry are developed from test results. By using rational analysis it is shown that prism strength can be predicted on the basis of linear behavior at failure. It is also shown that wall strength can be predicted on the basis of prism strength when an appropriate allowance is made for the effect of wall slenderness on sectional capacity.

BSS76. **Analysis of reinforced concrete beams subjected to fire,** B. Ellingwood and J. R. Shaver, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 76,* 83 pages (July 1976) SD Catalog No. C13.29/2:76.

Key words: creep; fire endurance; fire tests; reinforced concrete; sensitivity analysis; steel; structural mechanics; uncertainty.

Methods for analytically predicting the behavior of simply supported reinforced concrete beams subjected to fire are presented. This is generally a two-step process involving a thermal analysis followed by a stress analysis. This study emphasizes the latter, wherein the determination of moment-curvature-time relationships for the beam cross section incorporates the temperature-dependent strength degradation in the steel and concrete as well as thermal and creep strains. The sensitivity of the predictions to various phases of analytical modeling is investigated to establish the parameters most important for the prediction of beam behavior and to indicate where additional data should be gathered. A comparison of predicted behavior with that observed in fire tests shows excellent agreement when realistic reinforcement temperature histories are used.

BSS80. **Safety during construction of concrete buildings—A status report,** H. S. Lew, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 80,* 56 pages (Jan. 1976) SD Catalog No. C13.29/2:80.

Key words: building; codes; concrete; construction; falsework; formwork; loads; reshoring; safety; shoring; standards.

The current state-of-the-art of safety in concrete building construction is reviewed and summarized. The material presented considers only the technical aspects of the construction safety.

Safety of the individual in using equipment and in following construction procedures is not included in this study.

The report presents comparative accident frequencies in concrete construction. Based on reported construction failures, the relative vulnerability of various categories of concrete construction is estimated. The report examines causes of construction failures and reviews major regulatory standards at the federal, state, city and industry level affecting safety in concrete construction.

The factors which affect safety in concrete construction are examined relative to the state-of-the-knowledge and, where appropriate, recommendations are made for areas needing improved standards.

BSS81. **Survey of ground fault circuit interrupter usage for protection against hazardous shock,** R. W. Beausoliel and W. J. Meese, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 81,* 19 pages (Mar. 1976) SD Catalog No. C13.29/2:81.

Key words: branch circuit protection; electrical safety; electric shock; ground fault; leakage current; prevention of electrocution.

The ground fault circuit interrupter (GFCI) is increasingly becoming an integral part of building electrical systems to protect human life. Building researchers, designers, and contractors should have a working knowledge of their purpose and operational characteristics. This report describes the functional principles of GFCIs and relates their performance to effects of electric current on the human body. Information concerning the history, research and testing, installation practices, fire protection aspects, types, manufacturers and costs of GFCIs are included. The trend of requiring installation of GFCIs on more and more electrical circuits by regulatory authorities for safety purposes is outlined. Controversies concerning feasibility, reliability, nuisance tripping and other problems are discussed; laboratory and field investigations addressing these problems should be undertaken.

Permanent installations of GFCIs are being made in new residential and other construction, but very few are being installed in older buildings. The rationale for this needs to be examined. Because of higher leakage currents probable in most older construction, GFCIs manufactured under present standards may not be feasible in older buildings.

BSS82. **A new look at the research basis for lighting level recommendations,** G. T. Yonemura and Y. Kohayakawa, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 82,* 13 pages (Mar. 1976) SD Catalog No. C13.29/2:82.

Key words: gratings; illuminating engineering; lighting: modulation transfer function; suprathreshold visibility; visibility; vision.

The validity of using threshold studies as the basis for lighting level recommendations is questioned. The performance of the eye at suprathreshold levels was investigated with sine- and square-wave gratings. The results of the study indicate that the behavior of the eye is significantly different at suprathreshold levels as opposed to threshold levels. For threshold studies, when contrast is plotted against luminance, the function is a monotonically decreasing function. At suprathreshold levels the function indicates the existence of a definite minimum, luminances greater or less requiring more contrast to appear subjectively equal. It is recommended that lighting levels be based on laboratory studies that appraise visual requirements and performance simulating conditions encountered in real world environments.

BSS83. **Polymer impregnated hardened cement pastes and mortars,** J. R. Clifton, J. E. Fearn, and E. D. Anderson, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 83,* 21 pages (Apr. 1976) SD Catalog No. C13.29/2:83.

Key words: cement; compressive strength; flexural strength; fracture mechanics; polymer impregnated cement; polymer impregnated mortar; porosity; scanning electron microscopy.

Polymer impregnated hardened cement pastes and mortars have been prepared and their properties compared to those of control specimens. Specimens were made by impregnating dried and evacuated precast hardened cement pastes and mortars with methyl methacrylate, under pressure, which was thermally polymerized. The effects of the microstructure of the cement pastes and mortars on the performance of polymer impregnated mortars were determined by preparing specimens with a wide range of porosities by varying the water to cement ratio and the curing times prior to impregnation.

The properties of impregnated and control specimens were investigated by: scanning electron microscopy; porosity determinations; fracture mechanics studies; and strength determinations. The polymer impregnated materials had compressive and flexural strengths, moduli of elasticity, and fracture toughnesses which were substantially higher than unimpregnated materials.

BSS85. **Survey results for fire loads and live loads in office buildings,** C. G. Culver, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 85,* 157 pages (May 1976) SD Catalog No. C13.29/2:85.

Key words: buildings; fire loads; load surveys; occupancy live loads; structural engineering.

Fire load and live load data obtained from a survey of 23 office buildings located in various regions throughout the United States are presented. The survey design is described including the characteristics of the building population used to select the sample. Data are presented on the magnitude and distribution of the loads. Information is also included on the characteristics of office loads such as the type of items (furniture, equipment, etc.) and their properties (material type, dimensions, exposure, etc.). Statistical summaries of the data and a determination of the building and occupancy characteristics affecting these loads are presented. The data do not indicate any significant differences between the loads in private and government buildings. Similarly, geographic location, building height, and building age were not found to have a significant influence on load magnitude. The use of the rooms surveyed, however, did affect load magnitude. A mathematical model developed from a regression analysis of the survey data is presented for calculating fire loads and live loads in offices. The data presented may be used to evaluate current requirements for design loads for buildings.

BSS86. **Engineering aspects of Cyclone Tracy, Darwin, Australia, 1974,** R. D. Marshall, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 86,* 39 pages (June 1976) SD Catalog No. C13.29/2:86.

Key words: buildings; cyclones; disasters; structural engineering; tides; wind.

During the early morning hours of December 25, 1974, the city of Darwin was devastated by the most damaging cyclone ever to strike the Australian Continent. Winds of up to 75 m/s caused extensive damage to housing in particular, requiring the evacuation of approximately half of the 45,000 residents to other major cities in Australia. This report is a result of the author spending several days on temporary assignment with the Department of Housing and Construction – Australian Government to inspect the damage, and to participate in discussions regarding

the establishment of new design criteria and construction practices for cyclone areas. The fact that most of the damage was caused by wind forces rather than a combination of wind and storm surge greatly simplified the assessment of damage and structural performance. The experience at Darwin points out the danger in depending too heavily upon past experience and intuition in the design of housing. It also makes clear the need for additional research into the behavior of certain building materials under repeated loads and missile impact, and the racking strength of walls subjected to uplift loads.

BSS87. **Model documents for the evaluation, approval, and inspection of manufactured buildings,** P. W. Cooke, R. D. Dikkers, H. R. Trechsel, H. K. Tejuja, and L. P. Zelenka, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 87,* 296 pages (July 1976) SD Catalog No. C13.29/2:87.

Key words: building codes; certification; compliance assurance; evaluation; inspection; manufactured building; model documents; NCSBCS; standards; state regulation.

To assist the states in developing their building regulatory activities and functions, the Coordinated Evaluation System (CES) Project has defined and developed model informational documentation pertaining to the functional areas of (1) data submission, (2) evaluation, (3) approval, (4) compliance assurance, and (5) installation data.

This report gives the results of the project's investigations and presents sample model documents pertaining to manufactured buildings and building components. The model documentation is based on the Model Rules and Regulations for manufactured buildings developed by a Department of Commerce sponsored working task group, and the results of a comprehensive state-of-the-art study of most state building regulatory programs. The documentation presented covers all functional areas except owner information which is not usually subject to regulation. Emphasis was placed on developing documentation applicable primarily to one and two family detached dwellings.

BSS88. **Energy conservation in buildings—A human factors/systems viewpoint,** A. I. Rubin, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 88,* 19 pages (Nov. 1976) SD Catalog No. C13.29/2:88.

Key words: energy conservation; human factors; people in buildings.

The current emphasis on energy conservation in buildings must be balanced by a careful consideration of how proposed approaches affect building occupants. A head-long rush toward building designs which conserve energy at the expense of the quality of buildings as judged by occupants, would be a very shortsighted approach. There must be a continual awareness and sensitivity of the consequences on people when selecting among alternative "technical" options designed as a result of energy conservation needs. We need an increasing understanding of such factors as thermal comfort and illumination needs in buildings, as decisions likely to influence these requirements are made by designers.

Another area of concern which should not be overlooked is the interactions of people with their environments. "Hardware" approaches to energy conservation problems are often defeated by building occupants. Tight seals around doors and windows are useless if doors and windows are kept open. Building occupants have no choice but to turn all of the lights on or off if these are the only control options available to them. Building managers, operators and occupants have an important, though not well understood role to play in any energy conservation program. This problem deserves serious attention.

BSS89. **The incidence of abnormal loading in residential buildings,** E. V. Leyendecker and E. F. P. Burnett, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 89,* 10 pages (Sept. 1976) SD Catalog No. C13.29/2:89.

Key words: bombs; building codes; design criteria; explosions; gas; hazardous materials; loads; progressive collapse; sonic boom; vehicular collision.

The findings of an analysis of available U.S. statistics concerning the incidence of abnormal loading events in residential buildings are presented. The study evaluates natural gas explosions, bomb explosions, motor vehicle collision, sonic boom aircraft collision, and explosion of hazardous materials.

It is concluded that the gas related explosion, bomb explosion, and vehicular collision are of significance in building design for progressive collapse. Of these, the natural gas explosion is the most significant in terms of incidence. The gas explosion causing severe damage occurs with an annual frequency of 1.6 per million dwelling units and approaches a probability of 1×10^{-3} per apartment building per year.

BSS90. **The structure of building specifications,** S. J. Fenves, K. Rankin, and H. K. Tejuja, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 90,* 83 pages (Sept. 1976) SD Catalog No. C13.29/2:90.

Key words: building code provisions; building codes; building component classification; building specifications; building standards; performance concept.

This paper provides a scientific basis for the formulation and expression of performance standards and specifications and for explicit attention to performance in procedural and prescriptive standards and specifications.

The provisions of the NBS-developed *Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings,* a performance specification, are classified in terms of the physical entities addressed, the attributes of the built environment, and the properties which group together particular physical entities which may be subject to similar dysfunctions. These provisions are also subjected to a linguistic analysis which examines in detail the wording used and formalizes certain key concepts which are realized in the wording.

The provisions of the *Uniform Plumbing Code,* a prescriptive code, are classified in terms of the physical entities addressed and the performance attributes which can be inferred (though they are not explicitly addressed).

Guidelines for the expression of provisions in performance codes and specifications are presented. These guidelines are based on the classification studies and the linguistic analysis mentioned above.

BSS91. **The development of an improved test for evaluating the racking resistance of wall panels,** C. W. C. Yancey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 91,* 75 pages (Nov. 1976) SD Catalog No. C13.29/2:91.

Key words: lateral loads; loading rate; racking; test method; vertical loads; wall panels; walls.

An experimental investigation of the primary factors involved in the laboratory testing of prototype wall panels, under simulated wind-induced racking loads, is reported. The objective of the investigation was to recommend a static racking test method, generally applicable to a variety of wall construction types, that features realistic boundary and loading conditions. Initially, a literature survey was conducted for the purpose of evaluating the test methods which have been, or are being employed in determining the resistance of wall panels to static racking loads. In the

experimental program, 17 exploratory tests were conducted on a sample comprised of two types of wall panel construction. The 8 ft by 8 ft steel-frame and wood-frame panels were subjected to a combination of vertical and horizontal loading and their resulting deformation behavior was systematically monitored. Modifications to the testing procedure and to the boundary condition at the top of the panels were introduced as the experiments progressed. Detailed descriptions of the laboratory procedures used are presented. As the tests were developmental in nature and not intended for performance evaluation of the types of construction, selected results are presented. A static racking test method, applicable to traditional and innovative wall construction was derived as a result of the laboratory study and the literature survey. The principal new features of the proposed standard method are: (a) the application of distributed vertical loading, (b) the capability of testing panels of various height-to-width ratios and (c) the provision of top and bottom boundary conditions which do not force unrealistic modes of failure.

BSS92. **The viscosities of roofing asphalts at application temperatures,** W. J. Rossiter, Jr., and R. G. Mathey, *Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 92,* 44 pages (Nov. 1976) SD Catalog No. C13.29/2:92.

Key words: application temperature; asphalt; built-up roofing; interply thickness; roofing membranes; viscosity.

The optimum range of viscosity over which hot asphalt should be applied in the fabrication of built-up roofing membranes was determined to be 50 to 150 centistokes (mm^2/s). This viscosity range was based on the relationship between interply thickness and application temperature of asphalt obtained from roofing membrane specimens fabricated in the field. Because laboratory measurements showed a wide range of viscosities for roofing asphalts of the same type over their application temperature ranges, it was recommended that asphalts be applied at temperatures based on viscosity and not empirically determined temperature limits. In practice, the viscosity-temperature relationship should be determined for each roofing asphalt for the application temperature range prior to use. Using this relationship and the optimum viscosity range, the temperature range for applying each asphalt can be determined.

3.11. FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

Publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations). This series is available only from the National Technical Information Services, Springfield, VA 22161. See page 17 for price list.

FIPS PUB 38. **Guidelines for documentation of computer programs and automated data systems,** B. Marron, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 38,* 50 pages (1975).

Key words: automated data systems; computer programs; documentation; documentation content guidelines; FIPS guidelines; software.

These guidelines provide a basis for determining the content and extent of documentation for computer programs and automated data systems. Software development phases and related document types are identified, several examples of documentation options are given, and content guidelines for ten document types are provided. The ten document types are: Functional Requirements Document; Data Requirements Document; System/Subsystem Specification; Program Specification; Data Base Specification; Users Manual; Operations Manual; Program Maintenance Manual; Test Plan; Test Analysis Report.

The guidelines are intended to be a basic reference and a checklist for general use throughout the Federal Government to plan and evaluate documentation practices.

FIPS PUB 39. **Glossary for computer systems security,** D. Branstad and R. Krell, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 39,* 19 pages (Jan. 1976).

Key words: computer; data processing; definitions; Federal Information Processing Standards Publication; information processing; privacy; security; terms; vocabulary.

This glossary provides an alphabetic listing of approximately 170 terms and definitions pertaining to privacy, and security related to data, information systems hardware and software. Multiple word terms are listed in natural order, synonyms are referenced, and glossary terms appearing within a definition are indicated.

FIPS PUB 40. **Guideline for optical character recognition forms,** T. C. Bagg, Standard Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 40,* 60 pages (1976).

Key words: business forms; computers; data entry systems; information processing systems; information processing standards; OCR; OCR forms; optical character recognition; standards.

This publication provides materials relating to the design, preparation, acquisition, inspection, and application of OCR forms in data entry systems. Since the materials are advisory and tutorial in nature this publication has been issued as a guideline rather than as a standard in the FIPS publication series. Full color illustrations are employed to show specific features of reflective ink applications, a phenomena unique to OCR forms requirements. Appropriate references are made to cognizant standards in the OCR area.

FIPS PUB 44. **COBOL coding form,** M. V. Vickers, Standards Coordinator, *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 44,* 3 pages (1976).

Key words: COBOL; COBOL coding form; Federal Information Processing Standard; Federal Standard COBOL; software; standards conformance.

This publication provides a standard COBOL Coding Form (SF-268) together with an explanation of its use and physical specifications. The standard form is based upon a review and analysis of numerous COBOL coding forms being used throughout the Federal Government. The development of the standard form was accomplished through the cooperative efforts of FIPS Task Group 9 (COBOL) under the auspices of the National Bureau of Standards and the Interagency Reports and Standards Forms Division of the National Archives. It is anticipated that significant economic benefits will be realized by Federal departments and agencies as a result of the availability of a single standard form for government-wide use. This standard conforms to the provisions of Federal Standard COBOL (FIPS 21-1).

FIPS PUB 45. **Guide for the development, implementation and maintenance of standards for the representation of computer processed data elements,** H. S. White, Ed., *Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 45, 51 pages (1976).*

Key words: American National Standards; computers; data; data elements; data processing; information; information processing; International Standards; U.S. Government.

Provides technical and administrative guidelines for the development, use and maintenance of standards for representing data elements used in computer based systems. Basic concepts and terminology of data standardization are provided in addition to evaluation criteria for assessing various coding alternatives. The guide is used as a basic reference document in the development of Federal and voluntary national and international standards for data. The guide was developed by the X3L81 Standards Task Group of the American National Standards Institute and has been adopted for use by the International Organization for Standardization.

3.12. PRODUCT STANDARDS

Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. The National Bureau of Standards administers the Voluntary Product Standards program as a supplement to the activities of the private sector standardizing organizations.

PS64-75. **School paste.** *(ANS Z 297.2-1975),* C. W. Devereux, Technical Standards Coordinator, *Nat. Bur. Stand. (U.S.), Prod. Stand. 64-75,* 6 pages (Apr. 1976) SD Catalog No. C13.20/2:64-75.

Key words: paste, water-based, semi-liquid; school paste.

The purpose of this Voluntary Product Standard is to establish nationally recognized quality, safety, and packaging requirements for school paste and to provide a basis for common understanding among producers, distributors, and users of this product.

PS65-75. **Paints and inks for art education in schools.** *(ANS Z297.1-1975),* G. S. Chaconas, Technical Standards Coordinator, *Nat. Bur. Stand. (U.S.), Prod. Stand. 65-75,* 7 pages (Mar. 1976) SD Catalog No. C13.20/2:65-75.

Key words: art education; inks for art education; paints and inks; schools, paints and inks.

This Voluntary Product Standard covers the establishment of requirements for preservatives, toxicity, course particle content, performance, working qualities, and packaging for school paints and inks, and provides producers, distributors, and users with a basis for common understanding of the characteristics of this product.

PS66-75. **Safety requirements for home playground equipment.** *(ANS Z 304.1-1975),* J. M. Tascher, Technical Standards Coordinator, *Nat. Bur. Stand. (U.S.), Prod. Stand. 66-75,* 14 pages (July 1976) SD Catalog No. C13.20/2:66.75.

Key words: home playground equipment, safety of; jungle gyms, safety of; playground equipment, safety of; safety of home playground equipment; slides, safety of; swing sets, safety of.

This Voluntary Product Standard provides safety requirements for various types of home playground equipment intended for use by children aged from 2 through 10 years. The requirements are concerned with the design and performance of the units and their components, the structural integrity of the units and their components during and after exposure to static loads, and the instructions and information to be enclosed with the equipment. Methods of identifying products which comply with this standard are given.

3.13. TECHNICAL NOTES

Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other Government agencies.

TN594-11. **Optical radiation measurements: Development of an NBS reference spectrophotometer for diffuse transmittance and reflectance,** W. H. Venable, Jr., J. J. Hsia, and V. R. Weidner, *Nat. Bur. Stand. (U.S.), Tech. Note 594-11,* 47 pages (Oct. 1976) SD Catalog No. C13.46:594-11.

Key words: bidirectional reflectance factor; diffuse reflectance; diffuse transmittance; reflectance; spectrophotometry.

A new reference spectrophotometer, designed primarily for the analysis of diffuse transmittance and reflectance, has been developed in the Institute for Basic Standards at NBS. The spectrophotometer consists of a broad band monochromator with optional bandpasses of 2, 5, 10, and 20 nanometers. The exit aperture of the monochromator is provided with special mirror optics to collimate and switch the beam for optional use as a reference or sample beam. These collimated beams are directed into a dark room where a variety of sample mounts, light gathering devices, and detectors can be installed. Measurements for which provisions have been made or are planned include directional-hemispherical reflectance of solids, liquids, and powders, directional-hemispherical reflectance as a function of angle of incidence, diffuse transmittance, haze, and bidirectional reflectance factor. This technical note describes the design of the instrument in detail, and gives the results of the performance tests and detailed error analyses which have been carried out to date.

TN594-12. **Optical radiation measurements: The translucent blurring effect—Method of evaluation and estimation,** J. J. Hsia, *Nat. Bur. Stand. (U.S.), Tech. Note 594-12,* 31 pages (Oct. 1976) SD Catalog No. C13.46:594-12.

Key words: blurring effect; edge loss; error analysis; flux loss; plastics; reflectance; scattering; spectrophotometry; translucency; transmittance; Vitrolite glass.

The translucent phenomenon which causes flux loss in the spectrophotometric measurement is described. Methods for mathematically evaluating the flux loss are examined, and experimental methods using laser and conventional light sources are described. A widely used Vitrolite glass standard is employed to demonstrate the error estimation and correction.

TN670. **An infrared spectrometer utilizing a spin flip Raman laser, IR frequency synthesis techniques, and CO_2 laser frequency standards,** J. S. Wells, F. R. Petersen, G. E. Streit, P. D. Goldan, and C. M. Sadowski, *Nat. Bur. Stand. (U.S.), Tech. Note 670,* 54 pages (Jan. 1976) SD Catalog No. C13.46:670.

Key words: air quality measurements; improved resolution spectroscopy; infrared frequency measurements; infrared spectrometer; spin flip laser; tunable IR laser.

The central part of this spectrometer is a cw spin flip Raman laser which operates between 1900 and 1800 cm^{-1}. The spin flip laser has so far demonstrated capabilities of resolving spectra separated by 0.01 cm^{-1} and shows promise of exceeding this resolution capability. When used with an opto-acoustic detector or with a detector and a flow system, it is capable of making a variety of measurements of environmental interest. Many of these environmental applications require only wavelength metrology.

By using CO_2 laser standards as frequency references and incorporating infrared frequency synthesis techniques, spectroscopy with the spin flip Raman laser can be put on a frequency metrology basis. A CO_2 laser has been used with a metal-oxide-metal diode to synthesize a known frequency reference which was used to stabilize the CO pump laser. The MOM diode also has the potential for measuring the frequency difference between the SFRL and the CO pump laser, a step which will complete absolute frequency measurements with the SFRL. The progress toward achieving this goal, the potential capabilities of this unique spectrometer, and some future applications are discussed.

TN675. **Heat transfer and flow of helium in channels—Practical limits for applications in superconductivity,** M. C. Jones and W. W. Johnson, *Nat. Bur. Stand. (U.S.), Tech. Note 675,* 45 pages (Jan. 1976) SD Catalog No. C13.46:675.

Key words: buoyancy; channels; film boiling; forced convection; helium I; helium II; mixed convection; nucleate boiling; subcritical; supercritical; transition; turbulent flow.

Heat transfer and fluid mechanics of helium flowing in channels are reviewed. Emphasis is placed on observed or anticipated limits of operation which might be expected to apply in applications of superconductivity. Topics included are: the high-heat-flux degradation of heat transfer and possible effects of buoyancy forces in supercritical helium; transition to film boiling in subcritical helium; limiting heat currents in helium II; and the possibility of oscillations in forced flow helium systems.

TN677. **Laser attenuators for the production of low power beams in the visible and 1.06 μm regions,** B. L. Danielson and Y. Beers, *Nat. Bur. Stand. (U.S.), Tech. Note 677,* 25 pages (Jan. 1976) SD Catalog No. C13.46:677.

Key words: beam splitter; laser attenuation; neutral density filter.

Some methods were investigated for the accurate attenuation of laser beams to very low levels; approximately 10^{-11} watts. This work was done at 1.06 and 0.6471 μm, but the conclusions are applicable throughout the visible region as well. Two types of devices were considered: wedged beam splitters and neutral density filters. The theory of the attenuation of a wedged beam splitter was described and some of the errors associated with these devices were discussed.

TN678. **An electrically calibrated pyroelectric radiometer system,** C. A. Hamilton, G. W. Day, and R. J. Phelan, Jr., *Nat. Bur. Stand. (U.S.), Tech. Note 678,* 50 pages (Mar. 1976) SD Catalog No. C13.46:678, $1.25.

Key words: detector; pyroelectric; radiometry.

A new type of radiometer based on an electrically calibrated pyroelectric detector is described. Emphasis is placed on system design and analysis with careful consideration of design tradeoffs. An evaluation of both systematic and random errors for the complete system yields an expression for the accuracy relative

to the *electrical standards* by which it is calibrated. Throughout the paper the analysis should be sufficiently general that it can be applied to any Electrically Calibrated Pyroelectric Radiometer which employs the same basic principles.

TN679. **Frequency domain stability measurements: A tutorial introduction,** D. A. Howe, *Nat. Bur. Stand. (U.S.), Tech. Note 679,* 27 pages (Mar. 1976) SD Catalog No. C13.46:679.

Key words: fractional frequency fluctuations; frequency stability; phase fluctuations; power law noise processes; spectral density; spectrum analysis.

This report introduces the concept of stability measurements of oscillators by spectral analysis. Development of topics does not rely heavily on mathematics. The equipment and setup for stability measurements in the frequency domain are outlined. Examples and typical results are presented. Physical interpretations of common noise processes are discussed. The last section provides a table by which typical frequency domain stability characteristics may be translated to time domain stability characteristics.

TN680. **Application of infrared frequency synthesis techniques with metal-insulator-metal diodes to the spin flip Raman laser,** J. S. Wells, G. E. Streit, and F. R. Petersen, *Nat. Bur. Stand. (U.S.), Tech. Note 680,* 14 pages (Apr. 1976) SD Catalog No. C13.46:680.

Key words: frequency measurements on tunable lasers; IFS with a tunable laser; infrared frequency synthesis; SFRL frequency measurement; spin flip Raman laser.

Infrared frequency synthesis techniques with a metal-insulator-metal (MIM) diode have been extended to include the measurement of the frequency of a spin flip Raman Laser (SFRL). As a result of this extension, spectroscopy in the 5.3 μm region can be put on a frequency rather than a wave-length metrology basis. Additional observations with the diode are in qualitative agreement with recent work relating to nonlinear tuning over axial SFRL modes.

TN681. **A satellite-controlled digital clock,** J. V. Cateora, D. D. Davis, and D. W. Hanson, *Nat. Bur. Stand. (U.S.), Tech. Note 681,* 46 pages (June 1976) SD Catalog No. C13.46:681.

Key words: clock; microprocessor; satellite; time; time code.

A digital clock, resettable and controlled by the time code relayed by NOAA's SMS/GOES Satellites, is discussed. The clock's design is based upon a four bit microprocessor and uses the redundancy of the data to improve its performance. Satellite position is included in the clock's display for delay corrections to the received time.

A discussion of the generation, distribution, and reception of the time code is also included to aid the explanation of the clock's operation and performance.

TN682. **Implementation of the notch technique as an rf peak pulse power standard,** P. A. Simpson and P. A. Hudson, *Nat. Bur. Stand. (U.S.), Tech. Note 682,* 30 pages (July 1976) SD Catalog No. C13.46:682.

Key words: notch wattmeter; pulse-CW equalization; pulse modulated carrier systems; rf peak pulse power.

The theory and operation of a standard for measuring rf peak pulse power is described. The standard is based on the "notch" principle. It is constructed in coax for frequencies up to 4.4 GHz, and in WR-90 waveguide (8.2-12.4 GHz). The basic range is 1 to 10 mW but is extendable to cover 10 μW to 10 kW using directional couplers. Risetime of the system is 14 nanoseconds. A comprehensive error analysis is given. The uncertainty in coax is 3 percent and in waveguide is 4 to 6 percent depending upon peak power level.

TN683. **Models for the interpretation of frequency stability measurements,** J. A. Barnes, *Nat. Bur. Stand. (U.S.), Tech. Note 683,* 44 pages (Aug. 1976) SD Catalog No. C13.46:683.

Key words: flicker noise; frequency; frequency stability; oscillators; phase noise; stationary models.

The results of measurements of frequency stability are normally interpreted in the terms of models. Typically, these models are expressed as a power-law for the power spectral density (e.g., $S_y(f) = h_{-1}f^{-1}$). The experiments which provide the basis for these models are always limited in their range and include neither zero nor infinite Fourier frequency. Some authors have neglected the limits to the actual physical devices and the underlying data and have encountered mathematical difficulties with the models at either zero or infinite frequency or both. These problems are associated with the model and not the actual oscillators being modeled. By carefully taking into account actual limits of the device and constraining discussions to be concerned only with quantities which can be observed in a practical sense, one can avoid the problems of nonconvergence and nonstationarity.

Even for stationarity and convergent models, however, there is growing evidence that the typical Gaussian models may be inadequate. There appear to be occasional (sporadic) steps in the frequency of oscillators of a magnitude which is difficult to explain with conventional models.

TN684. **Thermophysical properties of ethane, from 90 to 600 K at pressures to 700 bar,** R. D. Goodwin, H. M. Roder, and G. C. Straty, *Nat. Bur. Stand. (U.S.), Tech. Note 684,* 326 pages (Aug. 1976) SD Catalog No. C13.46:684.

Key words: densities; enthalpies; entropies; equation of state; ethane; internal energies; isobars, isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; specific heats; speeds of sound; vapor pressures.

The thermophysical properties of ethane are tabulated at integral temperatures over the entire range of fluid states at temperatures from 90 to 600 K along isobars to 700 bar. A new form of the equation of state is employed for the first time. Thermodynamic functions in the compressed liquid at $T < T_c$ are obtained by use of specific heats C_v (T) along a high-density isochore, and C_σ (T) for the saturated liquid. Use of these new specific heat data and also of new PVT data provide the first reliable set of thermodynamic functions for compressed liquid ethane at temperatures below its normal boiling point.

TN686. **Ultrasonic calorimeter for beam power measurements,** T. L. Zapf, M. E. Harvey, N. T. Larsen, and R. E. Stoltenberg, *Nat. Bur. Stand. (U.S.), Tech. Note 686,* 36 pages (Sept. 1976) SD Catalog No. C13.46:686.

Key words: calorimeter; ultrasonic calorimeter; ultrasonic power measurements.

An ultrasonic calorimeter has been designed and constructed at the National Bureau of Standards for the measurement of beam power up to a few watts from ultrasonic transducers. The calorimeter, described as a twin, series flow, ultrasonic calorimetric comparator, operates in the frequency range from 1 to 15 MHz with uncertainties less than $\pm(7\% + 0.2$ mW). Twin vessels are provided so that thermal effects of an ultrasonic

sound beam absorbed in one vessel can be compared rapidly with accurately measured dc electrical power in the other vessel. Absorbing liquid enters each vessel near the ultrasonic input port. The temperatures of the absorbing liquid at the input ports are equalized by a heat exchanger, and the mass-flow rates are the same in both vessels. Twin temperature sensors, located in the output flow from the vessels, are connected in an electrical bridge circuit. In automatic operation the bridge is connected to a feedback circuit. With ultrasonic power introduced into one vessel, the feedback circuit promptly applies power to an electrical heater in the other vessel to regain bridge balance. The ultrasonic power then equals the measured dc power corrected for known errors.

TN687. **Measurement of rf power-absorption in biological specimens (10 to 100 MHz),** F. M. Greene, *Nat. Bur. Stand. (U.S.), Tech. Note 687,* 29 pages (Nov. 1976) SD Catalog No. C13.46:687.

Key words: electromagnetic field hazards; electromagnetic field synthesizer; electromagnetic radiation-exposure testing (nonionizing); near-fields; rf biological hazards.

A method is described for accurately determining the rf power being absorbed by a biological specimen during nonionizing radiation-exposure testing using the NBS RF Near-Field Synthesizer in the frequency range 10 to 100 MHz. This method is based solely on measuring the forward and reflected power on the transmission line feeding the synthesizer. Commercially available rf wattmeters can be used, and an automatic data-acquisition system employed, if desired, to "read" the meters and rapidly calculate, display, and record the rf power flow.

The method has the advantage that the exact measuring point on the feed line is not critical, as it is with methods employing direct impedance measurements, and that the required measurements can be made without interfering with the exposure tests.

TN688. **Yagi antenna design,** P. P. Viezbicke, *Nat. Bur. Stand. (U.S.), Tech. Note 688,* 27 pages (Dec. 1976) SD Catalog No. C13.46:688.

Key words: antenna; director; driven element; gain; radiation pattern; reflector; Yagi.

This report presents data, using modeling techniques, for the optimum design of different length Yagi antennas. This information is presented in graphical form to facilitate the design of practical length antennas—from 0.2λ to 4.2λ long—for operation in the HF, VHF, and UHF frequency range. The effects of different antenna parameters on realizable gain were also investigated and the results are presented. Finally, supplemental data are presented on the stacking of two or more antennas to provide additional gain.

TN689. **A simulation of the fluctuations of international atomic time,** J. A. Barnes, *Nat. Bur. Stand. (U.S.), Tech. Note 689,* 23 pages (Nov. 1976) SD Catalog No. C13.46:689.

Key words: frequency stability; international atomic time; models; simulation; time scale simulation.

In the Annual Report for 1975 the International Time Bureau (BIH) published estimates of noise levels which model the fluctuations in the International Atomic Time Scale (TAI). Based on these noise levels for each type of noise, an Auto Regressive, Integrated, Moving Average (ARIMA) model is constructed. A resulting ARIMA model, which can simulate time fluctuations in TAI, is given by the relation

$$(1 - \phi_1 B - \phi_2 B^2)\,\Delta^2 \chi_t = (1 - \theta_1 B - \theta_2 B^2 - \theta_3 B^3 - \theta_4 B^4) a_t$$

where χ_t represents the time fluctuations in nanoseconds (ns) of TAI measured at successive intervals of ten days; B is the index-lowering operator defined by $B^n \chi_t \equiv \chi_{t-n}$; Δ^2 is the second difference operator equivalent to $(1 - B)^2$; a_t are random, independent variables with a normal distribution, zero mean, and variance of $(147 \text{ ns})^2$ and the coefficients ϕ_i and θ_i are given by

$$\phi_1 = 1.79, \theta_1 = 2.93,$$

$$\phi_2 = -.795, \theta_2 = -3.12, \theta_3 = 1.419, \theta_4 = -0.233.$$

TN690. **Is hydrogen safe?,** J. Hord, *Nat. Bur. Stand. (U.S.), Tech. Note 690,* 38 pages (Oct. 1976) SD Catalog No. C13.46:690.

Key words: explosion; fire; fuel; gasoline; hydrogen; methane; safety.

The safety aspects of hydrogen are systematically examined and compared with those of methane and gasoline. Physical and chemical property data for all three fuels are compiled and used to provide a basis for comparing the various safety features of the three fuels. Each fuel is examined to evaluate its fire hazard, fire damage, explosive hazard and explosive damage characteristics. The fire characteristics of hydrogen, methane and gasoline, while different, do not largely favor the preferred use of any one of the three fuels; however, the threat of fuel-air explosions in confined spaces is greatest for hydrogen. Gasoline is believed to be the easiest and perhaps the safest fuel to store because of its lower volatility and narrower flammable and detonable limits. It is concluded that all three fuels can be safely stored and used; however, the level of safety risk for each fuel will vary from one application to another. Generalized safety comparisons are made herein but detailed safety analyses will be required to establish the relative safety of different fuels for each specific fuel application and stipulated accident. The technical data supplied in this paper will provide much of the framework for such analyses. Hydrogen safety guidelines, regulatory codes applicable to the distribution of hydrogen, and safety criteria for liquid hydrogen storage are compiled and presented.

TN691. **Clock synchronization and comparison: Problems, techniques and hardware,** J. E. Gray, *Nat. Bur. Stand. (U.S.), Tech. Note 691,* 12 pages (Nov. 1976) SD Catalog No. C13.46:691.

Key words: chronograph; frequency-stability measurement; instrumentation; laboratory technique; time measurement.

This report summarizes a lecture-discussion of practical problems in measurement electronics as experienced in a laboratory for precise timekeeping. It includes environment problems, instrumentation problems, procedural problems, and ends with a description of a convenient automatic measuring instrument, the chronograph.

TN889. **Trace hydrocarbon analysis: The National Bureau of Standards Prince William Sound/Northeastern Gulf of Alaska baseline study,** S. N. Chesler, B. H. Gump, H. S. Hertz, W. E. May, S. M. Dyszel, and D. P. Enagonio, *Nat. Bur. Stand. (U.S.), Tech. Note 889,* 73 pages (Jan. 1976) SD Catalog No. C13.46:889.

Key words: baseline studies; gas chromatography; gas chromatography-mass spectrometry; hydrocarbons; liquid chromatography; petroleum analysis; trace analysis.

The low concentration of hydrocarbons anticipated in pollution baseline studies necessitates the development of analytical techniques sensitive at the submicrogram per kilogram concentration level. The method of analysis developed in this laboratory involves dynamic headspace sampling for volatile hydrocarbon

components of the sample followed by coupled-column liquid chromatography for the nonvolatile components. These techniques require minimal sample handling, reducing the risk of sample component loss and/or sample contamination. Volatile sample components are separated from the matrix in a closed system and concentrated on a TENAX-GC packed precolumn, free from large amounts of solvent and ready for GC/GC-MS analysis. Nonvolatile compounds, such as the benzpyrenes, may be extracted from large volumes of water and concentrated on a Bondapak C18 packed precolumn for coupled-column liquid chromatographic separation and analysis. Results of the application of these techniques are presented and discussed.

TN891. **Issues in fire vehicle replacement: Users' views and synthesis,** P. B. Saunders, R. H. F. Jackson, P. R. Meyers, and M. H. Pearl, *Nat. Bur. Stand. (U.S.), Tech. Note 891,* 19 pages (Jan. 1976) SD Catalog No. C13.46:891.

Key words: engine pumper; fire vehicle; ladder truck; maintenance; replacement; specifications; standards.

This report documents the findings and recommendations from a study of fire vehicle replacement procedures. Exploration of that subject proved to require consideration of related issues arising in : (1) writing apparatus specifications, (2) maintaining and repairing vehicles, and (3) obtaining spare parts. The topics and most of the recommendations described herein are synthesized directly from visits and/or telephone interviews with fire department officials across the country. The recommendations of the study call for greatly increased communication among departments, the development of standards for vehicle performance, maintenance staff size, etc., and national and/or regional centers for training personnel and establishing standard vehicle testing procedures.

TN893. **Computer programs for structural chemistry: MATCH1 and MATCH2, FORTRAN programs to predict and evaluate mutual orientation of polycrystals,** B. Dickens and L. W. Schroeder, *Nat. Bur. Stand. (U.S.), Tech. Note 893,* 71 pages (Jan. 1976) SD Catalog No. C13.46:893.

Key words: computer calculations; crystal structure; epitaxy; lattice misfit; pattern recognition; twinning.

Two computer programs to evaluate possible structural matches for use in epitaxy and twinning studies have been written in FORTRAN V for the UNIVAC 1108. They should be readily convertible to other comparable computers.

The first program, MATCH1, requires knowledge of the unit cell parameters. It obtains all matching networks in two unit cell lattices and sorts the matches into an order of probable epitaxy (or twinning if the two unit cells are the same) based solely on criteria of dimensional mismatch and network area.

The second program, MATCH2, requires knowledge of positional parameters of the atoms in the crystal structures. It calculates the degree of structural fit for slices supplied from visual inspection of the crystal structures or as matching networks determined by MATCH1.

The slice comparison is carried out in terms of the vector set of the environment of each atom in each slice. The procedure is not valid when the twin operation is a rotation about the normal of the compositional plane or a reflection in a mirror parallel to this plane. The atomic patterns comprising the slices are matched piece by piece in MATCH2. A third program, MATCH3, will match whole patterns once three fiducial atoms in each pattern have been picked from the output of MATCH2 and will handle all the twinning cases. MATCH3 will be described in a future National Bureau of Standards Technical Note.

TN894. **Apparatus for testing oceanographic resistance thermometers,** G. T. Furukawa and J. L. Riddle, *Nat. Bur. Stand. (U.S.), Tech. Note 894,* 59 pages (Jan. 1976) SD Catalog No C13.46:894.

Key words: bridge; deep-sea thermometer; high pressure; oceanographic thermometer; platinum resistance thermometer; pressure; pressure intensifier; pressure seal; pressure vessel; resistance; resistance thermometer; test; thermometer; thermometer leads; thermostated bath; vacuum; water tight.

The design and construction of an apparatus for testing resistance-type oceanographic thermometers to 6.89×10^4 kPa(10,000 psi) are described. Detailed operating procedures for the apparatus are given. The results of performance tests with the apparatus are discussed.

TN895. **An overview of floor slip-resistance research with annotated bibliography,** R. J. Brungraber, *Nat. Bur. Stand. (U.S.), Tech. Note 895,* 113 pages (Jan. 1976) SD Catalog No. C13.46:895.

Key words: building safety; floor surface friction; occupancy safety; slip-resistance; slip-resistance testers; walking friction.

Slips and falls in the home as well as in public buildings have reached serious proportions (8,000,000 accidents per year in the home, resulting in 9,600 deaths and 1,600,000 disabling injuries). This paper reviews the literature relating to this problem. Based on studies of kinesiology and anthropometry, the coefficient of friction between foot surfaces and floor surfaces is found to be a significant parameter controlling slips and falls. A review of the general study of friction and a critical appraisal of methods for determining the coefficient of friction on slip-resistance of floors leads to a guide for selection of slip-resistance criteria. The paper concludes with a discussion of the legal aspects of the problem and the present status of slip-resistance specifications.

TN896. **NBS Reactor: Summary of activities July 1974 to June 1975,** R. S. Carter, *Nat. Bur. Stand. (U.S.), Tech. Note 896,* 150 pages (Jan. 1976) SD Catalog No. C13.46:896.

Key words: activation analysis; crystal structure; diffraction; isotopes; molecular dynamics; neutron; nuclear reactor; radiation.

This report summarizes all those programs which depend on the NBS reactor. It covers the period from July 1974 through June 1975. The programs range from the use of neutron beams to study of the structure and dynamics of materials through nuclear physics and neutron standards to sample irradiations for activation analysis, isotope production and radiation effects studies.

TN897. **Interpretation of data in the network measurement system,** S. W. Watkins and M. D. Abrams, *Nat. Bur. Stand. (U.S.), Tech. Note 897,* 46 pages (Mar. 1976) SD Catalog No. C13.46:897.

Key words: computer networks; data analysis; interactive; network service; performance evaluation; performance measurement; service.

The Network Measurement System (NMS) represents an implementation of a new approach to the performance measurement and evaluation of computer network systems and services. In this report, the interpretation of data within the NMS is described. These data have been acquired by the Network Measurement Machine (NMM) component of the NMS and are then interpreted by a Data Analysis Package (DAP), which produces meaningful information concerning the quality of network ser-

vice delivered to interactive terminal users as well as a characterization of user demands and network communication facility utilization.

This report traces the flow of data from the time of capture by the minicomputer-based NMM through the several phases of modeling and structuring in the DAP. Included in this description is the statistical treatment of the data which provides quantitative measures of various aspects of network performance.

TN898. **A prototype semi-automated system for measuring air infiltration in buildings using sulfur hexafluoride as a tracer,** C. M. Hunt and S. J. Treado, *Nat. Bur. Stand. (U.S.), Tech. Note 898,* 24 pages (Mar. 1976) SD Catalog No. C13.46:898.

Key words: air infiltration instrumentation; air infiltration measurement; building ventilation rates; sulfur hexafluoride tracer.

A system is described which automatically operates a small gas chromatograph and measures parts per billion concentrations of sulfur hexafluoride (SF_6) in air. It samples air on a 10 minute cycle and records the response on a strip chart recorder. When SF_6 is distributed in the air of a building, data is obtained from which air infiltration rates may be determined.

TN899. **Development of proposed standards for testing solar collectors and thermal storage devices,** J. E. Hill, E. R. Streed, G. E. Kelly, J. C. Geist, and T. Kusuda, *Nat. Bur. Stand. (U.S.), Tech. Note 899,* 265 pages (Feb. 1976) SD Catalog No. C13.46:899.

Key words: solar collector; solar energy; solar radiation; standard; standard test; thermal performance; thermal storage.

A study has been made at the National Bureau of Standards of the different techniques that are or could be used for testing solar collectors and thermal storage devices that are used in solar heating and cooling systems. This report reviews the various testing methods and outlines a recommended test procedure, including apparatus and instrumentation, for both components. The recommended procedures have been written in the format of a standard of the American Society of Heating, Refrigerating, and Air Conditioning Engineers and have been submitted to that organization for consideration.

TN900. **Deflection performance criteria for floors,** R. A. Crist and J. R. Shaver, *Nat. Bur. Stand. (U.S.), Tech. Note 900,* 29 pages (Apr. 1976) SD Catalog No. C13.46:900.

Key words: deflection; dynamic; floor systems; human responses; performance criteria; serviceability; static; vibration.

Serviceability performance criteria for floor systems are discussed in terms of their static and dynamic components. Development of traditional static stiffness criteria is given along with a review of their strengths and weaknesses. Criteria for serviceable floors are presented from a vibration viewpoint and the derivation of an improved criterion is given. A new approach for future vibration criteria is described.

TN901. **Comparison of theoretical and experimental photoeffect data 0.1 keV to 1.5 MeV,** J. H. Hubbell and W. J. Veigele, *Nat. Bur. Stand. (U.S.), Tech. Note 901,* 43 pages (Apr. 1976) SD Catalog No. C13.46:901.

Key words: attenuation coefficients; cross sections; gamma rays; photoelectric effect; photons; x rays.

Graphs of calculated and experimental atomic photoeffect cross sections as a function of photon energy 0.1 keV to 1.5 MeV are presented for all elements Z=1 to 94. The calculated results presented are (a) the nonrelativistic Hartree-Fock self-consistent-field (SCF) results of Veigele, Henry, et al., over the range 0.1 keV to between 1.0 and 8.0 keV for all elements Z=1 to 94 and (b) the relativistic Hartree-Slater SCF results of Scofield over the range 1.0 keV to 1.5 MeV for all elements Z=1 to 101. The "experimental" data-points are derived by subtracting theoretical scattering cross sections from total attenuation coefficient measurements in the literature. Differences between theoretical and experimental photoeffect data are typically a factor of two from 0.1 to 1.0 keV, 5-10 percent from 1.0 to 5.0 keV and 1-5 percent from 5.0 keV up to energies, ranging from 20 keV for carbon up to 500 keV for lead, above which the photoeffect cross section becomes fractionally too small to be accurately determined from the total attenuation coefficient.

TN902. **Evaluation, revision and application of the NBS stylus/computer system for the measurement of surface roughness,** E. C. Teague, *Nat. Bur. Stand. (U.S.), Tech. Note 902,* 151 pages (Apr. 1976) SD Catalog No. C13.46:902.

Key words: amplitude density function; arithmetic average; autocorrelation function; average wavelength; kurtosis; minicomputer software; random error; skewness; surface microtopography; surface roughness; surface texture; systematic error.

This report describes in detail the hardware and software used at NBS to implement on a stylus instrument/minicomputer system the process of calibrating the system with an interferometrically measured step and the calculation of important characterizations of surface profiles. The characterizations of a profile which may be calculated include the arithmetic average value, the mean square value, the amplitude density function, the autocorrelative function and the average wavelength. The report also includes a statistical evaluation, using empirical and analytical techniques, of the calibration procedures' long term stability.

TN903. **The NIRA computer program package (Photonuclear Data Center),** H. J. Vander Molen and H. M. Gerstenberg, *Nat. Bur. Stand. (U.S.), Tech. Note 903,* 30 pages (Feb. 1976) SD Catalog No. C13.46:903.

Key words: central computer; computer programs; data manipulation; digital data; mass storage; NIRA; Photonuclear Data Center.

The Photonuclear Data Center's NIRA library of programs, executable from mass storage on the National Bureau of Standard's central computer facility, is described. Detailed instructions are given (with examples), for the use of the library to analyze, evaluate, synthesize, and produce for publication, camera-ready tabular and graphical presentations of digital photonuclear reaction cross-section data. NIRA is the acronym for Nuclear Information Research Associate.

TN904. **Correlation of floor vibration to human response,** J. R. Shaver, *Nat. Bur. Stand. (U.S.), Tech. Note 904,* 29 pages (May 1976) SD Catalog No. C13.46:904.

Key words: analysis; experimental; floor systems; human response; random process; spectral analysis; vib tion.

A new approach to the problem of perceptible floor vibrations is presented predicated on the realization that human activity and human response to this activity are random variables. Techniques for data reduction are discussed and a detailed description of one approach is given along with the associated computer program. Data from floor vibrations is compared with current criteria for human response to vibration.

TN905. **A test method for determining the effect of thermal transients on pressure-transducer response,** J. S. Hilten, C. F. Vezzetti, J. F. Mayo-Wells, and P. S. Lederer, *Nat. Bur. Stand. (U.S.), Tech. Note 905,* 52 pages (Mar. 1976) SD Catalog No. C13.46:905.

Key words: calibration; dynamic; electronic flash; photographic flashbulb; pressure; pressure measurement; pressure transducer; thermal transient; transducer; zero shift.

A test method for evaluating the effects of short-duration, thermal radiant-energy transients on pressure-transducer response is described. The method consists of monitoring pressure-transducer output (zero shift with the transducer at atmospheric pressure) as the transducer is exposed to radiation resulting from the ignition of a photographic flashbulb or from the discharge of an electronic flash. The method is intended to serve as an initial screening test. Thermal energy pulses as great as 0.1 J/cm^2, with durations of about 6 ms, have been generated using an electronic flash; pulses of up to 2.2 J/cm^2, with durations of about 37 ms, have been generated using No. 22 flashbulbs. In tests with No. 22 bulbs, 25 commercial pressure transducers have shown zero shifts ranging from 0.4 to about 400 percent of the full-scale output.

TN906. **A methodology for evaluating alternative technical and information management approaches to privacy requirements,** R. C. Goldstein, H. H. Seward, and R. L. Nolan, *Nat. Bur. Stand. (U.S.), Tech. Note 906,* 72 pages (June 1976) SD Catalog No. C13.46:906.

Key words: computer security; confidentiality; cost model; data security costs; PL 93-597; privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs.

Cost becomes an early concern in applying privacy safeguards to any computerized record-keeping system. To determine privacy cost impact one requires a concrete and rigorous approach that permits repeated analysis of carefully documented assumptions. Such a methodology appears in the work reported in the book *The Cost of Privacy* by Dr. Robert C. Goldstein. This report represents the application of that methodology to the technical requirements flowing from the Privacy Act of 1974 (PL 93-579).

The methodology presented reduces the legislation to 17 compliance steps. Each compliance step then decomposes into one or more specific actions required of the record-keeper. The actions, in turn, translate into the expenditure of different resources. The resources, in dollars, are computed by a set of algorithms collectively called a privacy model and implemented as a computer program.

The privacy model contains algorithms reflecting resource expenditures for 56 distinct actions. Written as a FORTRAN program, the model produces several printouts that show the user the consequences of the input data. In addition to a total cost for conversion and an annual operating cost, the model provides sub-total costs for each compliance step. The model's potential uses include the comparison of costs associated with alternative safeguards, the selection of an optimal set of cost-effective safeguards, and the analysis of those factors having the greatest impact on costs.

TN908. **Measurement of computer communication networks,** M. D. Abrams, S. Treu, and R. P. Blanc, *Nat. Bur. Stand. (U.S.), Tech. Note 908,* 95 pages (July 1976) SD Catalog No. C13.46:908.

Key words: communications networks; computer networks; cost; interactive service; measurement; measures; performance; usability.

This report is concerned with aiding those responsible for the procurement of computer services from a Remote Access Network by providing a description of the measures, tools, and techniques applicable to the performance measurement of computer communication networks. Cost considerations are discussed as a major component of evaluation. Measurement and evaluation methodology are surveyed, including various operational tools and techniques. Some exemplary data are also presented. Although the constituents are already present, a neatly packaged methodological product, perhaps in the form of a well-structured user's guide to network performance measurement, is not yet available.

TN909. **Investigation of wind damage in the Metropolitan Washington, D.C. area, April 3-4, 1975,** F. Y. Yokel, C. W. Yancey, L. E. Cattaneo, and R. D. Marshall, *Nat. Bur. Stand. (U.S.), Tech. Note 909,* 65 pages (May 1976) SD Catalog No. C13.46:909.

Key words: building codes; design standards; masonry construction; roofs; siding; structural engineering; wind; wind damage; wind engineering.

A limited investigation was conducted of wind damage that occurred on April 3 and 4, 1975 in the Metropolitan Washington, D.C. area. Meteorological data indicate that the winds were somewhat less severe than those that should be anticipated by designers. Thus, most of the observed damage reflects inadequacies in design or construction. Damage was observed in occupied buildings, as well as in buildings under construction. Damaged elements of occupied buildings included: masonry curtain walls; masonry gable walls; masonry veneer; roofs with overhangs; roofing; and cladding. Damaged elements of buildings under construction included roofs and masonry walls.

TN910-1. **Self-study manual on optical radiation measurements: Part I—Concepts, Chapters 1 to 3,** F. E. Nicodemus, Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 910-1,* 93 pages (Mar. 1976) SD Catalog No. C13.46:910-1.

Key words: optical radiation measurement; photometry; radiometry; spectroradiometry.

This is the initial publication of a new series of Technical Notes (910) entitled "A Self-Study Manual on Optical Radiation Measurements." It contains the first three chapters of this Manual. Additional chapters will be published, similarly, as they are completed. The Manual is a definitive tutorial treatment of the measurement of incoherent optical radiation that is complete enough for self instruction. Detailed chapter summaries make it also a convenient authoritative reference source.

The first chapter is an introduction that includes a description of optical radiation and the ray approach to its treatment in this Manual (based on geometrical optics), a discussion of relevant parameters and their use in a measurement equation as a systematic technique for analyzing measurement problems, and a presentation of the system of units and nomenclature used.

The second chapter, on the distribution of optical radiation with respect to position and direction, introduces the basic radiometric quantity, radiance, and its important invariance properties. It is shown how to determine the total power in a beam from the radiance distribution and to determine the distribution of radiance at any surface, through which the beam passes, in terms of the distribution at any other surface that also intersects the entire beam.

TN912. **The network measurement machine—A data collection device for measuring the performance and utilization of computer networks,** R. Rosenthal, D. E. Rippy, and H. M. Wood,

Nat. Bur. Stand. (U.S.), Tech. Note 912, 91 pages (Apr. 1976) SD Catalog No. C13.46:912.

Key words: computer networks; data acquisition; man-machine interaction; minicomputer; network measurement; performance measurement.

The Network Measurement Machine (NMM) is a device used to acquire data for the performance measurement of computer network systems and services. By focusing on the service delivered to network customers at their terminals, measurements can be made that are directly relevant to user needs and to management concerns.

This technical report presents the details of a data acquisition device. The device is a minicomputer-based system that employs regular (off-the-shelf) and special purpose hardware under the control of a specially written software acquisition system. The technical aspects of inserting the NMM into the data communications portion of a computer network are discussed. The detailed nature of both the hardware and the software data acquisition system is presented with a discussion of the important design decision trade-offs.

TN913. **Modification of an NBS reference spectrophotometer,** K. L. Eckerle, *Nat. Bur. Stand. (U.S.), Tech. Note 913,* 43 pages (July 1976) SD Catalog No. C13.46:913.

Key words: averaging spheres; high accuracy transmittance; light averaging devices; linearity; photometric precision; reference spectrophotometer; ultraviolet; wavelength calibration.

The description of a new reference spectrophotometer capable of making transmittance measurements accurate to 0.0001 transmittance units has already been reported. The purpose of this publication is to describe some modifications that have been made to this instrument and to report some further measurements performed with it. The extension of the range of the instrument down to 200 nm, providing a capability for making measurements over the spectral range 200 to 800 nm, is outlined, and extensive testing of the light averaging effectiveness of several types of devices and spheres is reported here.

TN914. **A new dynamic pressure source for the calibration of pressure transducers,** C. F. Vezzetti, J. S. Hilten, J. F. Mayo-Wells, and P. S. Lederer, *Nat. Bur. Stand. (U.S.), Tech. Note 914,* 35 pages (June 1976) SD Catalog No. C13.46:914.

Key words: calibration; dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer.

A dynamic pressure source is described for producing sinusoidally varying pressures of up to 34 kPa zero-to-peak, over the frequency range of approximately 50 Hz to 2 kHz. The source is intended for the dynamic calibration of pressure transducers and consists of a liquid-filled cylindrical vessel, 11 cm in height, mounted upright on the armature of a vibration exciter which is driven by an amplified sinusoidally varying voltage. The transducer to be calibrated is mounted near the base of the thick-walled aluminum tube forming the vessel so that the pressure-sensitive element is in contact with the liquid in the tube. A section of the tube is filled with small steel balls to damp the motion of the 10-St dimethyl siloxane working fluid in order to extend the useful frequency range to higher frequencies than would be provided by an undamped system.

The dynamic response of six transducers provided by the sponsor was evaluated using the pressure sources; the results of these calibrations are given.

TN915. **Metrication problems in the construction codes and standards sector,** C. T. Mahaffey, *Nat. Bur. Stand. (U.S.), Tech. Note 915,* 25 pages (June 1976) SD Catalog No. C13.46:915.

Key words: building regulations; dimensional coordination; metric conversion; planning and scheduling.

This report is a response to a request for an outline of problems to be faced by the building standards development and building regulatory sectors of the American building industry. It includes a discussion of the SI metric units themselves, giving examples of the conventions regarding their use adopted in other countries to illustrate the nature of the decisions that must be made by the U.S. building industry. It discusses the relationship of dimensional coordination to the metric conversion effort, its impact on the U.S. building regulatory system and illustrates some of the decisions these sectors need to make. It also discusses some of the organizational problems required to involve all segments of the industry in this decision-making process, and for implementing these decisions in a coordinated way on a national scale.

TN916. **Software exchange directory for university research administration,** Z. G. Ruthberg and G. R. Bolotsky, *Nat. Bur. Stand. (U.S.), Tech. Note 916,* 215 pages (Apr. 1976) SD Catalog No. C13.46:916, $2.80.

Key words: directory; equipment management software; fiscal administration software; grant/contract software; personnel management software; proposal/award software; research administration; software exchange; software summary; software survey; space management software; university systems.

The Institute for Computer Sciences and Technology (ICST) at the National Bureau of Standards (NBS) has developed a Software Exchange Directory for the University Research Administration under a contract with the Research Management Improvement Program (RMIP) at the National Science Foundation (NSF). The one hundred Universities and Colleges receiving the largest Federal funding for research and development were sent an Office of Management and Budget (OMB) approved survey instrument developed for this purpose at ICST. Seventy-five institutions sent responses suitable for 83 Directory entries under Administrative Information and 315 Directory entries under Software Package Summaries. An administrative entry contains information on the reporting unit, the basic administrative structure and parameters, computer usage, automated functional areas, and comments. A package entry contains a functional description, software and hardware characteristics, history, availability and comments. The administrative entries have been indexed by funding size, size of research staff, number of Federal granting agencies, and number of contracts and grants awarded in Fiscal Year 1974. The software packages have been indexed by function, computer used and language used. The detailed entries and indexes should help open communication channels for this community of computer users and thus maximize transferability of these programs between institutions. They also draw a comprehensive state-of-the-art picture of this area of computer use.

TN917. **A review of network access techniques with a case study: The network access machine,** R. Rosenthal, *Nat. Bur. Stand. (U.S.), Tech. Note 917,* 36 pages (July 1976) SD Catalog No. C13.46:917.

Key words: access procedures; command language; computer networks; job control language; macros; minicomputers; protocols; teleprocessing.

The computer industry's ability to serve a diverse and expanding user community is evidenced by the rapid growth of computer network services. Computer service providers design and market their own offerings as they deem best, given their own market and their own set of resources. This has led to a proliferation of similar resources requiring different user access procedures. With emphasis on currently operating and planned systems that assist users in accessing available network services, this report identifies the techniques used in network access devices. By examining these devices, the trend toward improving the interface between the user and the computer is brought more clearly into focus and up to date.

One specific solution—A Network Access Machine (NAM)—is described in detail. The NAM is a minicomputer system that acts as a network access point for a user at his terminal and assists the user through the automatic execution of access procedures. This minicomputer facility allows the user to specify (or to have specified) his own network command sequences for execution on a specified network and host connected to that network. Computer responses are analyzed to assure agreement with those anticipated for specific commands. Conditional parameterized expansions allow the use of the same commands on different host computer and different networks.

TN918. **Survey of building code provisions for historic structures,** M. Green and P. W. Cooke, *Nat. Bur. Stand. (U.S.), Tech. Note 918,* 47 pages (Sept. 1976) SD Catalog No. C13.46:918.

Key words: building codes; cities; health and safety; historic preservation; states.

In order to resolve conflicts between health and safety objectives and historic preservation objectives, a number of states and cities have adopted special building code provisions. A survey was conducted to determine the extent of adoption of such special provisions. The survey included the states, territories and member cities of the Association of Major City Building Officials (AMCBO). The survey responses revealed that sixteen of the forty-seven responding states have special provisions or regulations as do fifteen of the twenty-four responding cities. The majority of states and cities have established a special preservation appeals board. Legislation and special provisions are reviewed in the report. Recommendations for additional research are included.

TN919. **Operating system structures to support security and reliable software,** T. A. Linden, *Nat. Bur. Stand. (U.S.), Tech. Note 919,* 51 pages (Aug. 1976) SD Catalog No. C13.46:919.

Key words: capability; capability-based addressing; computer security; extended-type objects; operating system structures; protection; reliable software; reliability; security; small protection domains; types.

Security has become an important and challenging goal in the design of computer systems. This survey focuses on two system structuring concepts that support security; namely, small protection domains and extended-type objects. These two concepts are especially promising because they also support reliable software by encouraging and enforcing highly modular software structures—in both systems software and in applications programs. Small protection domains allow each subunit or module of a program to be executed in a restricted environment that can prevent unanticipated or undesirable actions by that module. Extended-type objects provide a vehicle for data abstraction by allowing objects of new types to be manipulated in terms of operations that are natural for these objects. This provides a way to extend system protection features so that protection can be enforced in terms of applications-oriented operations on objects. This survey also explains one approach toward implementing these concepts thoroughly and efficiently—an approach based on the concept of capabilities incorporated into the addressing structure of the computer. Capability-based addressing is seen as a practical way to support future requirements for security and reliable software without sacrificing requirements for performance, flexibility, and sharing.

TN920. **Use of synthetic benchmarks for estimating service bureau processing charges,** D. M. Conti, *Nat. Bur. Stand. (U.S.), Tech. Note 920,* 47 pages (July 1976) SD Catalog No. C13.46:920.

Key words: benchmarking; charging algorithms; service bureaus; synthetic benchmarking; workload characterization.

This report describes the development of a new synthetic benchmark technique for estimating batch processing charges at service bureau sites. This technique was used to estimate the cost of processing a large batch workload at a number of service bureaus within the same mainframe family. The method was found to be low-cost, yet reasonably accurate for a certain class of service bureau charging algorithms. Refinements of this method are suggested which will extend its applicability to other algorithms. The procedures used to create and run the benchmark, together with the projection of total workload cost are described.

TN921. **Survey manual for estimating the incidence of lead paint in housing,** W. G. Hall and L. T. Slovic, *Nat. Bur. Stand. (U.S.), Tech. Note 921,* 111 pages (Sept. 1976) SD Catalog No. C13.46:921.

Key words: lead paint; lead paint detection; lead paint programs; lead poisoning; portable x-ray fluorescence; random sampling; x-ray fluorescence.

This manual is intended as a guide for municipal managers in performing a survey to determine the prevalence of lead based paint in their community's dwelling units. There are four parts to the Manual, each is intended for a different audience.

Part I discusses the preliminary considerations for a survey. It is intended for the department head or executive who will initiate plans for the survey. It presents a managerial overview of the processes, the cost determinants, criteria for the establishment of objectives and the resources required.

Part II is intended for the survey manager and the inspector supervisors. It contains more detailed information on the planning, staffing, training, and execution of the data collection phase of the survey.

Part III is for the use of the person responsible for the control and management of the data collected and for the analysis of these data.

The Appendices contain quite detailed information about procedures we have used in previous surveys. These may be used as they are described or may be modified or adapted to meet specific objectives.

TN922. **Economic analysis of experimental lead paint abatement methods: Phase I,** R. E. Chapman, *Nat. Bur. Stand. (U.S.), Tech. Note 922,* 112 pages (Sept. 1976) SD Catalog No. C13.46:922.

Key words: abatement; building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning.

Public and private concern about the potential for lead poisoning in children due to the ingestion of lead-based paint chips has

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resulted in a Federally sponsored program to develop technologies by which lead-based paint may be eliminated from the nation's housing. Through this program lead-based paint abatement techniques were tested in field deleading operations conducted in Washington, DC, and Atlanta, GA. The program also focused on the collection of data on the direct costs of labor, materials and special equipment associated with these abatement techniques.

This report provides a statistical analysis by abatement technique and building component (i.e., walls, doors, door frames, windows and frames, and miscellaneous trim) of this direct cost data. Abatement techniques are then ranked according to their relative costs. A cost model is developed for each category (ranking) which identifies the key factors which affect direct cost and provides a framework whereby direct costs may be estimated. Recommendations are made for further refinement of the model; a methodology through which the optimal combination of lead-based paint abatement techniques can be identified is also outlined.

TN923. **Applications of thermography for energy conservation in industry,** C. W. Hurley and K. G. Kreider, *Nat. Bur. Stand. (U.S.), Tech. Note 923,* 31 pages (Oct. 1976) SD Catalog No. C13.46:923.

Key words: energy conservation; energy surveys; infrared; nondestructive evaluation; thermographic surveys; thermography.

Infrared thermography has been developed as a tool to measure the temperature of various types of surfaces. Notable applications include thermal detection of diseases such as cancer and circulatory problems in human beings, aerial land mapping of hot surfaces to detect thermal pollution and geological formations, and remote scanning of buildings to detect heat losses. More recently, infrared scanning has been used to detect defects in high amperage electrical connections, transformers, and steel processing furnaces in industrial environments.

It was the intent of the NBS IR program to build on these technologies to assist energy conservation engineers to assess heat losses in industrial plants. IR teams from the NBS Center for Building Technology had previously used the equipment to survey heat losses in buildings where the IR camera was found to be particularly useful in detecting infiltration problems, missing insulation, and construction defects. Our intent in this project was to survey furnaces and heating systems in addition to electrical and mechanical systems to find areas suggesting energy conserving actions. This qualitative survey has been found to be an excellent method to detect heat losses in unit process equipment and auxiliary systems. This survey method described in this paper was carried out in fifteen industrial plants in order to develop a methodology and examine the feasibility of the approach.

In addition to the qualitative survey quantitative data was gathered by calibrating the temperature of the "hot spots" uncovered in the survey. This information was very useful in developing priorities and estimating the magnitude of the heat loss due to a given defect.

TN924. **Procedures for the calibration of ASTM E127-type ultrasonic reference blocks,** D. J. Chwirut, G. F. Sushinsky, and D. G. Eitzen, *Nat. Bur. Stand. (U.S.), Tech. Note 924,* 43 pages (Sept. 1976) SD Catalog No. C13.46:924.

Key words: aluminum ultrasonic reference standards; ASTM-type reference standards; calibration; interim reference standard; longitudinal beam; measurement system; nondestructive evaluation; pulse-echo; ultrasonics.

A service for the calibration of ASTM E127-Type ultrasonic reference blocks has been established at the National Bureau of Standards. A single well-characterized reference block, carefully chosen to be as close as possible to "typical" or "nominal," has been designated as an interim standard against which other blocks can be compared. As refinements are made and the system becomes better understood, new standards may be developed leading to the development of an absolute national standard. The facilities and procedures used in this calibration service are described herein.

TN925. **Overviews and justifications for low gravity experiments on phase transition and critical phenomena in fluids,** M. R. Moldover, R. J. Hocken, R. W. Gammon, and J. V. Sengers, *Nat. Bur. Stand. (U.S.), Tech. Note 925,* 99 pages (Oct. 1976) SD Catalog No. C13.46:925.

Key words: critical point; gravity effects; phase transitions.

Important scientific questions concerning pure fluids and fluid mixtures near critical points are identified and are related to the progress of several disciplines. Consideration is given to questions about thermodynamic properties, transport properties, and the complex nonlinear phenomena which occur when fluids undergo phase transitions in the critical region. We discuss, quantitatively, the limitations to answering these questions by experiments in the earth's gravitational field. The distinction is made between practical limits which may be extended by advances in technology and intrinsic ones which arise from the modification of fluid properties by the earth's gravitational field. The kinds of experiments near critical points which could best exploit the low gravity environment of an orbiting laboratory are identified. These include studies of the index of refraction, constant volume specific heat, and phase separation.

TN927. **Development of dynamic calibration methods for pogo pressure transducers,** J. S. Hilten, P. S. Lederer, C. F. Vezzetti, and J. F. Mayo-Wells, *Nat. Bur. Stand. (U.S.), Tech. Note 927,* 58 pages (Nov. 1976) SD Catalog No. C13.46:927.

Key words: bias pressure; calibration; dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; pressure transducer; sinusoidal; space shuttle; transducer.

Two dynamic pressure sources are described for the calibration of pogo pressure transducers used to measure oscillatory pressures generated in the propulsion system of the space shuttle. Rotation of a mercury-filled tube in a vertical plane at frequencies below 5 Hz generates sinusoidal pressures up to 48 kPa, peak-to-peak; vibrating the same mercury-filled tube sinusoidally in the vertical plane extends the frequency response from 5 Hz to 100 Hz at pressures up to 140 kPa, peak-to-peak. The sinusoidal pressure fluctuations can be generated by both methods in the presence of high pressure (bias) up to 55 MPa.

Calibration procedures are given in detail for the use of both sources. The dynamic performance of selected transducers was evaluated using these procedures; the results of these calibrations are presented. Calibrations made with the two sources near 5 Hz agree to within 3 percent of each other.

TN928. **Computer programs for the evaluation of activity and osmotic coefficients,** B. R. Staples and R. L. Nuttall, *Nat. Bur. Stand. (U.S.), Tech. Note 928,* 56 pages (Dec. 1976) SD Catalog No. C13.46:928.

Key words: activity coefficients; aqueous; computer programs; data evaluation; electrolytes; electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic properties; vapor pressure.

A number of specialized computer programs have been developed for the purposes of calculating thermodynamic properties directly from experimental data and for subsequent data manipulation, including nonlinear least-squares fitting of the data to empirical or semiempirical equations that describe the function over a range of compositions, temperatures or other parameters. The details of the programs used in the critical evaluation of mean activity and osmotic coefficients and sample runs for each program are discussed. Osmotic coefficients can be calculated from direct vapor pressure measurements or from isopiestic molalities. Activity coefficients can be calculated from electromotive force measurements of galvanic cells, both without liquid-junction and with transference. A nonlinear least-squares program fits data from all sources as a function of ϕ and ln γ. Once the parameters of the fitting equation have been obtained, another program can be used to calculate a table of m, γ, ϕ, a_w, and ΔG^{ex} at rounded molalities.

TN929. **A survey of current literature on sampling, sample handling, and long term storage for environmental materials,** E. J. Maienthal and D. A. Becker, *Nat. Bur. Stand. (U.S.), Tech. Note 929,* 40 pages (Oct. 1976) SD Catalog No. C13.46:929.

Key words: chemical analysis; environmental samples; long-term storage; microbiologicals; organics; pesticides; radionuclides; sample handling; sampling; trace elements.

This article is the result of an extensive literature survey to establish optimum sampling, sample handling and long term storage techniques for a wide variety of environmental samples to retain sample integrity. The components of interest in these samples are trace elements, organics, pesticides, radionuclides or microbiologicals. This survey was done both manually and by use of various bibliographical retrieval services. Also the advice and opinions of workers in various aspects of the fields was obtained.

TN930. **A measurement assurance program for electric energy,** N. M. Oldham, *Nat. Bur. Stand. (U.S.), Tech. Note 930,* 23 pages (Sept. 1976) SD Catalog No. C13.46:930.

Key words: electric energy; electricity; electric power; measurement assurance; transport standard; watthour meter.

A Measurement Assurance Program for Electric Energy is described which enables a meter laboratory to evaluate the accuracy of its calibration process relative to the legal units of energy maintained by the National Bureau of Standards. A laboratory participating in this program periodically determines its process offset by testing an NBS transport standard as part of its regular workload (using the same procedures used to test its working standards). Subsequent monitoring and tests for local control can improve the reliability and assure the adequacy of the participant's calibration process.

TN931. **Environmental effects on microphones and type II sound level meters,** E. B. Magrab, Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 931,* 120 pages (Oct. 1976) SD Catalog No. C13.46:931.

Key words: acoustic calibrators; A-weighting; barometric pressure; crest factor; ground cover; humidity; instrumentation; microphones; sound level meters; statistical control processes; temperature.

For four different manufacturer's Type II sound level meters numerous experimentally determined data concerning the effects of frequency, temperature, angle of incidence of the sound, and types of ground cover and reflecting surfaces on sound level meter readings are presented. Data are also given for the effects of ambient barometric pressure on several manufacturers' acoustic calibrators, the effect of frequency and crest factor on the sound level meters' detector circuit, the linearity of the sound level meters' range potentiometer and meter scale, and the precision of the A-weighted response in a randomly incident (diffuse) sound field. Additional data are given concerning the effects of temperature and humidity on the sensitivity of electret, condenser, and ceramic microphones. Finally, important statistical concepts and recommended data monitoring procedures are presented to insure that the precision of repeated sound level measurements is known.

TN932. **Concrete strength during construction,** H. S. Lew, T. W. Reichard, and J. R. Clifton, *Nat. Bur. Stand. (U.S.), Tech. Note 932,* 56 pages (Dec. 1976) SD Catalog No. C13.46:932.

Key words: compressive strength; concrete; maturity; mechanical properties; nondestructive evaluation; pull-out strength; splitting tensile strength.

The early strength gain characteristics of a concrete at various temperatures was investigated in this study. In addition, the applicability of two widely known nondestructive evaluation methods were examined for the purpose of determining the compressive strength of concrete at early ages.

For destructive evaluation, standard cylinder compression tests, splitting tensile tests and pull-out tests were made on specimens cured at 73 °F (22.8 °C), 55 °F (12.8 °C) and 35 °F (1.7 °C). For nondestructive evaluation, both probe penetration and rebound hammer tests were performed on slabs. Tests were carried out at the age of 1, 2, 3, 5, 7, 14, 28 and 42 days after casting the concrete.

Statistical analyses were made to examine the possibility of using maturity of concrete as a parameter to correlate test results of concrete cured at different temperatures. Rate of gain of the splitting tensile strength, pull-out bond strength and elastic modulus were compared with that of compressive strength.

The results show that when related to maturity, the rate of increase in the splitting tensile strength is about the same as that of the compressive strength, whereas the rate of increase in the pull-out strength and the modulus are slightly greater than that of the compressive strength. The results of nondestructive evaluations revealed that the compressive strength could not be estimated correctly by the probe method using the manufacturer's conversion charts. Because of lower rebound readings, the rebound hammer could not be used to estimate the compressive strength at early ages.

3.14. CONSUMER INFORMATION SERIES

Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

No publications issued in this series during this period.

3.15. NBS INTERAGENCY REPORTS

A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution by the National Technical Information Service (NTIS), Springfield, Va. 22161, in paper copy or microfiche form unless otherwise stated. When ordering this series from NTIS you must order it by the "COM, PB, or AD" number listed at the end of each entry.

NBSIR 73-264. **Examination of failed one inch black iron pipe natural gas service line, Iowa Public Service Company, Eagle Grove, Iowa,** T. R. Shives, 24 pages (Aug. 30, 1973). Order from NTIS as PB243541.

Key words: black iron pipe; dimpled rupture; ductile fracture; gas pipe.

A fractured one inch black iron pipe natural gas service line which connected to a building involved in an explosion and fire in Eagle Grove, Iowa, on February 2, 1973, was examined by the NBS Mechanical Properties Section. The fracture was ductile in nature. There was no evidence found to indicate the presence of a preexisting crack. The fracture appeared to have been due to bending stresses caused by loading from an external source.

NBSIR 73-299. **Examination of failed eight inch welded steel pipe natural gas main, UGI Corp., Coopersburg, Pennsylvania,** M. L. Picklesimer and T. R. Shives, 35 pages (Nov. 1973). Order from NTIS as PB243543.

Key words: brittle fracture; gas main pipe; welded steel pipe.

The Office of Pipeline Safety, Department of Transportation, submitted a four foot length of eight inch diameter welded steel pipe natural gas main containing a crack in the weld to the NBS Mechanical Properties Section for examination. The apparent crack origin was located at about the 4:30 o'clock position, assuming the top of the pipe to be at twelve o'clock and the outside of the bend of the pipe as installed was at three o'clock. The crack had propagated about two-thirds of the way around the pipe circumference. Optical and scanning electron microscopy revealed the fracture to have been predominantly brittle in nature. There was lack of weld penetration around a large part of the weld circumference and the weld metal exhibited some porosity. These features are normal for steel pipe welded by the oxyacetylene practice used at the time the weld was made. While these features of the weld helped to define the path of the fracture, they probably did not contribute to it. Examination of the fracture and comparison of its features with those of fractures produced in the laboratory indicated that failure was probably brought about as a result of a single event, impact loading from an external source.

NBSIR 73-423. **Guidelines for the use of computer technology in the developing countries,** R. A. Simmons, 172 pages (Dec. 1973). Order from NTIS as COM 74-11722.

Key words: computer education and training; computer technology; less-developed countries; technology transfer; U.S. foreign assistance.

The objective of this report is to contribute to more effective use of computer technology by the developing countries. An intensive survey of computer use and development in nine selected countries and an analysis of other supporting data have resulted in the formulation of specific conclusions. Recommendations for guidance of responsible officials in the developing countries and in the Agency for International Development have been developed in response to the conclusions and are presented in summary form. Later sections of the report include the facts and discussions in support of the conclusions, with emphasis on the responsibilities of the national governments, the problems of education and training, present computer applications, and the role of ADP standards. The results of the individual country surveys are included in the appendix. The report is a part of joint efforts on the part of the Department of Commerce and the Agency for International Development to bring U.S. high technology more effectively to bear on the problems of economic and social development in the less-developed countries of the world.

NBSIR 74-371. **Broadband pulsed/CW calibration signal standard for field intensity meter (FIM) receivers,** P. A. Simpson, 53 pages (June 1974). Order from NTIS as COM 74-11567.

Key words: broadband signal generator; impulse bandwidth; receiver bandwidth calibration; rf burst generator; spectral intensity.

This report describes the constructional details and the operation of a system for calibrating microwave field intensity meter (FIM) receivers in the frequency range 1 to 12.4 GHz. The system uses known levels of CW power to calibrate the receiver, and short duration (~20 ns) rf bursts to measure the bandwidth. An error analysis of the system is given. Schematic drawings of various circuits in the system are provided along with charts and tables for facilitating computations encountered when performing calibrations.

NBSIR 74-452. **Design and evaluation criteria for energy conservation in new buildings,** Staff of the Center for Building Technology, NBS, 107 pages (Feb. 27, 1974). Order from NTIS as PB204586.

Key words: air leakage; building design; energy conservation; fenestration; HVAC systems; illumination; insulation; lighting; performance standard; thermal performance; ventilation; water heating.

This document contains design and evaluation criteria for energy conservation in most new buildings. It was prepared in response to a request by the National Conference of States on Buildings Codes and Standards to the National Bureau of Standards. It is intended to be the forerunner of a consensus standard to be promulgated by a national standards organization.

The requirements and criteria are performance-oriented to the extent permitted by present building design technology. The performance concept is applied at the subelement or subsystem level to synthesize an energy-efficient total system. The detailed criteria are directed toward the design of building envelopes with good thermal resistance and low air leakage, and toward practices in the design of mechanical and electrical systems which conserve energy. Design flexibility is achieved by providing for the acceptance of alternative design solutions that can be shown to save equivalent amounts of energy without following every detailed requirement.

NBSIR 74-507. **Mercurous chloride polarizer material,** R. Forman, W. S. Brower, and H. S. Parker, 31 pages (June 1, 1974). Order from NTIS as ADA000343.

Key words: infrared; mercurous chloride; polarizer material; visible.

This contract report covers a feasibility study on the potential use of mercurous chloride crystals for construction of prism polarizers, primarily for the infrared region of the spectrum. In particular, the research has consisted of crystal growth from the vapor phase and optical characterization of the absorption, dichroism, and birefringence.

Crystal growth has been performed in quartz or Vycor ampoules sealed off under a pressure of 10^{-5} torr or better. Crystals are grown in a vertical modified Bridgman furnace by vapor transport. Repeated regrowth has been found to produce a continuous improvement in clarity, the best samples being virtually colorless. The growth rates used of 2 mm/day in tubes of 17 mm inside diameter have been found to be satisfactory for producing the crystals used to date, but strain patterns and a tendency to polycrystallinity indicate that slower growth rates should be attempted. Conditions for growth have not yet been optimized, but reasonably good growing conditions have been delineated.

Single crystal samples have been oriented by Laue backreflection techniques and measurements made of optical absorption, dichroism, and birefringence. Proper sample handling procedures have been determined to minimize thermal shock and thermal etching. The index of refraction has been measured at selected wavelengths, and calorimetric absorption studies have been performed at AFML on some of the samples produced.

NBSIR 74-518. **Instrumental colorimetry of retroreflective sign materials,** I. Nimeroff and W. A. Hall, 89 pages (Aug. 1974). Order from NTIS as PB239633.

Key words: colorimetry; highway signs; photoelectric tristimus colorimeters; photometry of retroreflective materials; retroreflective sign materials.

Because color-coded applications of highway signs increase, specifications of colors and color tolerances are required. In order to assure that the requirements are met within specified regions, a measurement technique needs to be developed and described. To accomplish these goals the U.S. Department of Transportation contracted with the National Bureau of Standards to conduct the required studies and make the necessary recommendations. Having previously performed a study for daytime conditions, the National Bureau of Standards was competent to perform a study for nighttime conditions. The colorimetric properties of 126 samples of retroreflective materials of 7 different colors were measured with 3 telecolorimeters in simulated nighttime conditions. One spectrophotometer was used to measure color of 38 of the samples in simulated daytime conditions. The colors measured were: red, orange, brown, yellow, green, blue and silver (white). Differences of color measured by means of different telecolorimeters on the same samples were evaluated.

As a result of these studies procedures for making colorimetric and photometric measurements were developed and are included in this report. On the basis of the color measurements and their variability tentative recommendations for color boundaries were prepared and are also included in this report.

NBSIR 74-625. **Examination of failed two inch steel pipe natural gas main, Columbia Gas Company, Spring Garden Township, York County, Pennsylvania,** T. R. Shives, 41 pages (Jan. 1975). Order from NTIS as PB243547.

Key words: brittle fracture; gas main pipe; impact; low carbon steel; stress corrosion cracking.

The Mechanical Properties Section of the National Bureau of Standards examined a length of a cracked two inch diameter plain carbon, welded steel natural gas main pipe at the request of the Office of Pipeline Safety. The pipe had a transverse crack extending about 85 percent of the circumference. The pipeline had suffered considerable mechanical damage in the vicinity of the failure, and the crack, which propagated in an essentially brittle manner, appeared to have initiated in a gouged area near the bottom of the pipe. There was a considerable amount of corrosion product on the surface of the pipe in the gouged area. The amount and distribution of corrosion product on the fracture surface indicated that the crack had formed in at least two stages, and that a crack was present prior to the time of failure. During the first stage, the crack may have penetrated the entire wall thickness of the pipe in one region opposite the crack origin near the bottom of the pipe. The likely mechanism of fracture for the first stage of the crack appears to be stress corrosion cracking. For the second stage of the crack, either stress corrosion cracking or impact appears to be the likely mechanism of failure.

NBSIR 75-667. **Interaction of blood proteins with solid surfaces,** R. R. Stromberg, B. W. Morrissey, L. E. Smith, W. H. Grant, and C. A. Fenstermaker, 42 pages (Jan. 15, 1975). Order from NTIS as PB241267.

Key words: adsorption; blood protein; bound fraction; ellipsometry; implants; polymer adsorption; protein adsorption; synthetic implants.

The adsorption of blood proteins on surfaces has been investigated in order to develop a detailed understanding of the initial series of events that occur when a synthetic material is implanted in the cardiovascular system. The overall objective of the investigation is to help provide a rational basis for the characterization and design of materials and the development of test methods. The relationship between surface charge and protein-surface interaction was investigated quantitatively by in situ ellipsometry to determine the molecular extension and adsorbance of fibrinogen, serum albumin, and γ-globulin on platinum as a function of impressed surface potential. For all three proteins, no change in adsorbance from the value at rest potential occurred as the surface potential was progressively made more anodic until a critical potential was attained, at which time the adsorbance increased significantly. The changes in extension observed as a result of changes in induced surface potential indicated, however, that conformational changes in the adsorbed layer were occurring as a result of surface potential. The determination of the bound fraction (fraction of carbonyl groups directly in contact with the surface) and extension of adsorbed γ-globulin and β-lactoglobulin as a function of solution concentration indicate conformational changes with surface population. Similar measurements on γ-globulin crosslinked prior to adsorption indicate that the native conformation exists at low surface coverage. Investigation of the rates of desorption of albumin from silica into buffer indicates a fast initial desorption followed by a considerably slower desorption removing most, but not all, of the adsorbed protein during the time periods investigated.

NBSIR 75-678. **Analysis of construction systems for the thermal classification of residential buildings,** S. T. Liu, 59 pages (Nov. 24, 1975). Order from NTIS as PB248687.

Key words: building classification; building thermal mass; building thermal performance; building thermal time constant; housing systems; industrialized housing; mass per unit area; Operation BREAKTHROUGH; U-value.

This report is the result of a study to classify various kinds of residential buildings in relation to their thermal behavior. A collection of various building data and construction systems taken from the proposals of 18 of the 22 Housing System Producers participating in the Department of Housing and Urban Development (HUD) Operation BREAKTHROUGH Program is presented. Thermal performance parameters of buildings, such as: U-value, thermal mass, thermal time constant, and mass per unit area were computed and analyzed. The report recommends one way in which construction systems could be classified. Since the housing systems studied represented a cross section of the conventional residential construction systems in the building industry, it is felt that a realistic classification procedure for typical residential buildings can be established and based upon the parameter: mass per unit area. A more refined procedure of subdividing the building within each mass class on the basis of the building thermal time constant is also discussed.

NBSIR 75-692. **A minicomputer-based system for the measurement and analysis of community noise,** R. L. Fisher, D. S. Blomquist, J. S. Forrer, and D. M. Corley, 106 pages (May 1975). Order from NTIS as PB250385.

Key words: community noise; computer interface; instrumentation; minicomputer; noise.

An operating system for the measurement and analysis of community noise was turned over to the Army for their use in February 1975, thus accomplishing the transfer of technology developed by NBS to the Bioacoustics Division, U.S. Army Environmental Hygiene Agency. This report documents the hardware and software packages prepared by NBS in support of this system.

NBSIR 75-706. **Calculations of radiant heat flux in the proposed floor covering flame spread test apparatus,** J. Quintiere and K. Bromberg, 21 pages (Dec. 1975). Order from NTIS as PB248640.

Key words: floor covering; heat flux; radiant panel test method.

Calculations have been made to determine the radiant heat flux distribution to the test specimen in the proposed radiant panel flame spread test for floor covering materials. Comparison with measured heat flux indicates a significant heat transfer contribution from the enclosure of the test apparatus. Also, nonuniformities in the temperature of the radiant panel affect the resultant flux distribution. Based on these results, it is expected that two similar test apparatuses would not have identical heat flux profiles along the specimen. Additional calculations were made to illustrate possible heat flux profiles capable with the present apparatus under various panel temperatures and orientations.

NBSIR 75-719. **A compliance testing system for NILECJ,** R. Mills, 24 pages (Feb. 1976). Order from NTIS as PB251410.

Key words: acceptance testing; compliance testing; laboratory evaluation; performance testing; qualified products lists; testing.

In order to assure that NILECJ equipment standards have the impact intended, a Compliance Testing and Laboratory Accreditation program is needed to establish which items available on the market do, in fact, meet the requirements of the standards. This report contains recommendations for such a NILECJ program. In brief, the proposed program would (a) result in a body of qualification and acceptance test data, (b) establish a list of testing laboratories competent to perform these tests, and (c) set up a "compliance information system" for the dissemination of this information to officials in the criminal justice system.

NBSIR 75-722. **Closure testing equipment instruction manual,** M. S. Morse, 42 pages (Oct. 1975). Order from NTIS as PB248641.

Key words: bottle caps; child protection; closure testing; containers; medicine bottles; poison packaging.

The NBS Closure Testing Equipment is designed to make accurate measurements of the critical parameters of the "childproof" closures required by the Poisoning Prevention Packaging Act of 1971. In general, these parameters are defined as the forces necessary to open these closures, either in the manner by which the closure was designed to be opened, or in an undesired manner. This manual discusses the design and construction of the testing instrument and gives detailed instructions for its operation.

NBSIR 75-735. **An expandable total energy data editor,** R. H. F. Jackson, 151 pages (Aug. 1976). Order from NTIS as PB256295.

Key words: computers; data editing; energy conservation.

This report documents the Total Energy Data Editor, a computer program developed to process the data to be collected by the ongoing Total Energy Project at the National Bureau of Standards. Consisting of a mix of FORTRAN and RAYTHEON machine language subroutines, the Editor is a powerful, interactive program written to be run on a Raytheon 704 minicomputer with two tape drives and a disk pack. Since this document is also meant as a user's manual, it includes a dictionary of commands, complete discussions and listings of individual subroutines, as well as an explanation of the workings of the program.

NBSIR 75-742. **Mixed oxides for fuel cell electrodes,** U. Bertocci, M. I. Cohen, W. S. Horton, T. Negas, and A. R. Siedle, 56 pages (Jan. 1976). Order from NTIS as PB248744.

Key words: electrocatalysis; fuel cells; mixed oxides; oxygen reduction; phosphoric acid; ternary metal-sulfur arrays; transition elements; triphenylphosphine; tungsten bronze.

Studies of mixed oxides were made in order to determine if such materials could act as oxygen-reducing electrocatalysts in an acid fuel cell. Included were strontium and barium cobaltates and manganates with and without added titanium; lanthanum titanates, with and without calcium or strontium; calcium, strontium, and barium ruthenates; and mixed oxides of the systems Ti-Ta-O, V-Nb-O, Ce-Ta-O, Pr-Ta-O, Ce-Nb-O, and Ce-Pr-Ta-O. Choices were based upon producing variable valence and upon conferring stability at elevated temperatures ($\leq$ 150 °C) in phosphoric acid. Barium ruthenate and the systems Ti-Ta-O, V-Nb-O, V-Ta-O, Ce-Ta-O, were hot-acid stable. The thermal reactions of $CeTaO_{4+x}$ with $O \leq x \leq 0.5$ were studied in air up to about 1960 °C.

Potentiodynamic and galvanostatic studies are reported on materials from the Ti-Ta-O system, TiO_2 as grown, TiO_2 reduced with hydrogen, TiO_2 with 0.1 percent Nb, lanthanum titanates with and without calcium or strontium, a tungsten bronze, barium ruthenate, and strontium titanate with 0.03 and with 0.15 percent Nb.

Preparation of inorganic compounds with ternary metal-sulfur arrays similar to the arrays in nitrogen reductase was attempted. The following were made: $(Ph_3P)_4Cu_2W_2S_6$, $(Ph_3P)_6Ag_5W_2S_6O_2$, and $[(Ph_3P)_3Ag]_2W_2S_6$, where Ph_3P refers to the triphenylphosphine moiety. Also prepared were $(Ph_3PAu)_2W_2S_4$, $(Ph_3AsAu)_2WS_4$, (diphos)$NiWO_2S_2$, (diphos)$_2Pd_3W_2S_6O_2$, and $(Ph_3P)_3PtW_2S_6O_2$, where "diphos" refers to 1,2-bis(diphenylphosphino)ethane.

NBSIR 75-750. **The calibration of indexing tables by subdivision,** C. P. Reeve, 38 pages (July 1975). Order from NTIS as PB249934.

Key words: angle standard; autocollimator; calibration; complete closure design; indexing table; least squares estimation; partial closure design; standard deviation; subdivision; variance-covariance matrix.

The indexing table plays a vital role in the calibration of angle standards at the National Bureau of Standards. It is often useful to know the values of several different intervals on the table as precisely as possible. The usual measurement designs call for a complete intercomparison of two tables which are being calibrated simultaneously. Two new types of measurement designs have been developed which call for only a fraction of this effort. One type of design subdivides the entire circle on each table into equal segments, and the other design subdivides these into smaller segments. Together the designs form a flexible system for calibrating any desired intervals on the two tables. Formulae are given for the propagation of random errors through all levels of subdivision. An example is included.

NBSIR 75-751. **Thermodynamics of chemical laser and high temperature species,** C. W. Beckett, 37 pages (Oct. 1975). Order from NTIS as ADA017626.

Key words: chemiluminescent; diatomic molecules; dissociation energies; high temperature; PbO; thermophysical measurements.

This report (covering July 1974 through June 1975) gives summaries (a) for high-speed thermophysical measurements on hafnium, iron, tantalum, and molybdenum and (b) for an interpretation of the Raman spectra of PF_5, AsF_5, and VF_5. Details of these activities have been or are in the publishing process. In addition, this report includes two articles which are current and have not started the publication process. One is a study on the chemiluminescence of the $Pb(g)+O_3(g)$ reaction, and the other is a review of the literature for dissociation energies of diatomic oxides and fluorides relevant to chemical lasers in the visible region. Finally, some related bibliographies on chemical kinetics are indicated.

NBSIR 75-755. **The CPSC road test of bicycle braking performance—Experimental evaluation,** D. E. Marlowe, 32 pages (Aug. 1975). Order from NTIS as PB248642.

Key words: bicycles; braking; consumer safety; handbrake; safety; testing.

The brake performance criteria to be published as part of a mandatory regulation on bicycle safety requirements has been evaluated. Fifteen bicycles were tested in accordance with the regulation. A mathematical adjustment of the actual test speed of the bicycle to 24 km/hr (15 mph) is necessary before the weight allowance can be made to the stopping distance in the evaluation of these tests. A danger of injury to the test rider exists during the tests and future efforts should be made toward replacement of these tests with a simpler laboratory procedure.

NBSIR 75-757. **A technique for the measurement of flash fire potential of polymeric materials,** J. E. Brown and J. J. Comeford, 33 pages (Dec. 1975). Order from NTIS as PB248914.

Key words: aircraft fires; fire hazard; flash fire; polyurethane; pyrolysis.

This report summarizes work for the period February-August 1974 on a continuing program to characterize the chemical and physical parameters of importance in a flash fire and to develop laboratory scale methods for measuring the flash fire potential of materials.

Significant modifications have been made to a flash-fire cell developed earlier to measure the flash fire potential of materials by characterizing the condition required to produce an ignitable pyrolyzate-air mixture by thermally degrading a polymer. The furnace temperature, cell geometry and orientation, and sample size are specified. These modifications have resulted in an improved technique, especially in terms of reproducibility, for evaluation of flash fire potential of materials.

Experiments have been conducted on rates of combustible gas formation from flexible polyurethanes to assist in the optimization of the flash-fire cell operating conditions.

In the rate study, two successive major stages of degradation were found for polyurethane as the temperature approached 500° at a rate of about 60 °C/min. It was also found that the products of the second stage appear to be responsible for flash fires in the flash-fire cell. A minimum polyurethane weight to enclosure volume ratio greater than 0.2 g/l and a sample pyrolysis temperature greater than 380 °C were required to produce a flash fire in this apparatus.

NBSIR 75-768. **Reevaluation of the densities of the four NBS silicon crystal standards,** H. A. Bowman, R. M. Schoonover, and C. L. Carroll, 36 pages (Aug. 1975). Order from NTIS as PB247943.

Key words: density standard; phase shift; silicon.

There were a few features of our recently completed density standard experiment which were based upon ideas which, we believe, should be changed. This report lists these changes and their justification. The result is to increase the assumed values of the densities of the crystals by about 1.7 ppm. The new assumed values are: $X2 = 2.329\,1289$ g/cm^3; $X3 = 2.329\,1253$ g/cm^3; $X4 = 2.329\,1228$ g/cm^3; $X5 = 2.329\,1226$ g/cm^3.

Additionally, we now believe that the densities of the crystals are stable, and not appreciably changing due to oxidation—a point left unresolved in our published report.

NBSIR 75-775. **Electrical measurement of high voltage pulses in diagnostic x-ray units,** R. E. Hebner, Jr., 62 pages (Nov. 1, 1975). Order from NTIS as PB248684.

Key words: calibration; electrical measurements; electro-optics; frequency response; high voltage; Kerr effect; operational amplifier; pulses; radiation; safety; x-ray generators; x rays.

The report describes a method of calibrating dividers used to measure high voltage pulses in diagnostic x-ray units. The experimental development emphasized four areas. These were the divider ratio under direct voltage, the frequency dependence of the ratio, the voltage dependence of the ratio and the effect of self-heating on the device. The results of measurements on approximately fifteen different dividers are summarized.

In addition, this report contains two appendices. The first discusses conventional and electro-optical methods of measuring the high voltage pulses, while the second presents a more detailed analysis of the feasibility of electro-optical measurement of these pulses.

NBSIR 75-779. **The development of an improved compression test method for wall panels,** C. W. C. Yancey and L. E. Cattaneo, 107 pages (Dec. 1975). Order from NTIS as PB249935.

Key words: compression; eccentric loading; flat-end; kern; loading rate; pin-end; test method; wall panels; walls.

An experimental and analytical investigation of the primary factors involved in the testing of prototype wall panels under axial compression loading is reported. The objective of the investigation was to develop a method of testing wall specimens that incorporates the best features of ASTM Standard Method E72 while at the same time incorporating improvements in the areas of deficiency in the Standard. Twenty-five laboratory tests were conducted on samples composed of five types of wall panel construction. The panels were tested to failure under either of two different eccentricities of load, while being supported with one of two types of idealized end conditions. Selected test results and detailed descriptions of the laboratory procedures used are presented. A computer-aided analytical study of the variables affecting the degree of uniformity of loading was conducted. Equations based on the analogy of beams supported on elastic foundations were used in the analysis. A study of the statistical parameters commonly used to interpret test results was conducted to establish useful guidelines for predicting structural performance on the basis of small sample test results. A compression test method applicable to traditional and innovative wall constructions is presented. The principal additions in the revised test method are as follows: (a) a provision for variable eccentricity, (b) a procedure for selecting a load distribution assembly which will be compatible with the test panel.

NBSIR 75-782. **Full-scale corridor fire experiment using a glass fiber carpet,** L. H. Breden, 33 pages (Dec. 1975). Order from NTIS as PB248643.

Key words: carpet; corridor test; fire testing; flammability; glass fiber.

A corridor fire experiment was carried out using a glass fiber carpet. It was observed that with a fuel loading of 2.7 pounds per square foot of wood in an adjacent fire room, no propagation of the fire occurred down the corridor. The glass fiber carpet in the burn-room became discolored and there was a significant weight loss of the carpet directly in contact with the fire. The carpet did not produce significant levels of smoke and did not spread the fire into the corridor.

NBSIR 75-786. **The CPSC road test of bicycle braking performance—Kinetic and error analyses,** L. Mordfin, 75 pages (Oct. 1975). Order from NTIS as PB251411.

Key words: bicycle brakes; brakes, bicycle; dynamics, bicycle; error analysis; friction, tire/pavement; kinetics, bicycle; measurements, bicycle braking; pitchover; standards, bicycle safety; test method, bicycle.

The Consumer Product Safety Commission has promulgated a safety standard for bicycle braking systems based on the stopping distances achieved in road tests under specified conditions. This report presents an error analysis of the test method, for the Commission's use in justifying or modifying the test criteria. The error analysis is based on experimental data, for the most part, and on theoretical principles where sufficient data are lacking. The theory, a kinetic analysis of the bicycle braking process, is included in the report together with proposed definitions of terms intended to quantify important aspects of bicycle braking performance.

The error analysis produced estimates of rather large lab-to-lab and test-to-test variabilities to be expected from the test method. These, in turn, were found to be principally dominated by errors resulting from an incorrect overweight-rider allowance specified by the Commission, and by variations in rider reaction times, respectively. Suggestions are made for more accurate methods of accommodating variations in rider mass, for reducing the effects of the test-to-test variability, and for reducing the danger of pitchover in the performance of the road test.

NBSIR 75-788. **Evaluation of the fire hazard in a mobile home resulting from an ignition on the kitchen range,** E. K. Budnick and D. P. Klein, 28 pages (Feb. 1976). Order from NTIS as PB250843.

Key words: fire test; flame spread; kitchen cabinets; kitchen range; kitchen range hood; limited combustibility; mobile home.

A series of fire tests was conducted in a typical mobile home to evaluate the potential fire hazard resulting from an accidental ignition from cooking on the kitchen range. Specific attention was directed to (a) ease of ignition of the kitchen cabinets as a function of the clearance between the range and the underside of the cabinets with and without the presence of a metal hood and (b) flame spread following the ignition.

The tests, which used a preheated pan of cooking oil as an ignition source, were conducted in a mobile home kitchen area. The materials tested were printed lauan plywood, printed particle board, and molded polystyrene, representative of materials used in kitchen cabinet construction in mobile homes.

Under the test conditions employed, it was found that ignition of the kitchen cabinets occurred in all cases in which a metal hood was not used. The time to ignition of the materials was only slightly affected by the clearance between the specimen (cabinet bottom) and the range. A significant time delay or no ignition resulted from the installation of a metal range hood.

An additional problem area revealed by the tests was the ignition and burn-through of the partition directly behind the range.

Specific design recommendations based on test results are presented along with suggestions for further investigation.

NBSIR 75-790. **FY75 progress report on design criteria and methodology for construction of low-rise buildings to better resist typhoons and hurricanes,** R. D. Marshall and N. J. Raufaste, Jr., 362 pages (Nov. 1975). Order from NTIS as PB250848.

Key words: buildings; codes and standards; housing; hurricanes; low-rise buildings; natural disaster; structural connections; typhoons; wind loads.

This report represents the major accomplishments conducted during the third phase (FY75) of a three year project to develop improved design criteria for low-rise buildings in developing countries to better resist extreme winds. The research study sponsored by the Agency for International Development commenced in March 1973. Two other reports were prepared: NBSIR 74-582 FY73 Progress Report (first phase of the research—4 months) and NBSIR 74-567 FY74 Progress Report (second phase of the research—12 months). During FY75, 6 major tasks were completed (instrumentation of fifth and sixth of six test houses to collect full scale field wind data, continuation of technician training at the field sites and at the wind tunnel facility, analyzed of extreme wind data, development of draft improved design criteria reports, participation in regional conferences in Manila and scheduling of regional dissemination of project results conference in Jamaica for November 1975). Research activities will be completed in December 1975. A final report will be published by the end of FY76.

NBSIR 75-791. **Procedural options for modification of architectural glass in residences to improve occupant safety,** S. W. Stiefel, 57 pages (Dec. 1975). Order from NTIS as PB253229.

Key words: architectural glass products; Consumer Product Safety Act; residence-related products; residential safety modification; safety implementation approaches.

The U.S. Consumer Product Safety Commission has the responsibility for developing and promulgating mandatory safety standards for products which pose unreasonable risks of injury for consumers. One of the first products selected for development of a safety standard under the Consumer Product Safety Act of 1972 was architectural glass. The prospects for regulation of many other residential unit component parts are wide open. Nevertheless, the initial impact of the adoption of a mandatory standard for architectural glass would be rather limited. The limited impact is largely due to the fact that people will continue to occupy existing housing that will not be immediately subject to the new rule.

This report documents the second and final phase of a project which considered the possible modifications for architectural glass products and the means for encouraging their implementation. The report evaluates available injury data, defines the population of hazardous architectural glass products and compares the relative level of hazard among the products. A set of possible retrofit options is presented, suggested by accident pattern review, and criteria are developed, which are useful in assessing their effectiveness. A model has been developed and exercised to calculate benefit-cost ratios for retrofit modification based upon averted injury medical costs attributable to injuries prevented by product modification. A set of implementation approaches has been postulated for consideration by the CPSC, for encouraging safety modification of component parts of residential units.

NBSIR 75-801. **A bibliography on automated measurements (July 1, 1969, to July 1, 1974),** G. A. Teamer and A. Y. Rumfelt, 158 pages (Apr. 1976). Order from NTIS as PB252044.

Key words: automated measurements; computer-aided measurements; computer-controlled instruments.

This bibliography lists approximately 1000 citations pertinent to the field of automated measurement of electrical/electronic quantities and characteristics. In addition, approximately 400 citations are included that should be helpful in applying computers to the automation of measurements. Only references appearing in the open literature between July 1, 1969, and July 1, 1974, are listed.

NBSIR 75-805. **Calibration techniques for electromagnetic hazard meters: 500 MHz to 20 GHz,** R. R. Bowman, 38 pages (Apr. 1976). Order from NTIS as PB252971.

Key words: calibrations; electromagnetic hazards; field meters; gain; microwave; near-field.

The calibration techniques discussed are suitable for producing fields for calibrating most electromagnetic (EM) hazard meters to within ±1.0 dB using a minimum of laboratory space and oscillator power. Above about 2.6 GHz, adequate equipment and standards have been available for these calibrations. Below this frequency the large apertures of the usual horn radiators require more power than is available from medium power oscillators. Further, calibrations in closed systems are difficult except at frequencies well below 1 GHz. Thus there is a need for small-aperture gain standards from about 500 MHz to 2.6 GHz. The main portion of the work reported here consists of accurate gain measurements for open-ended hollow waveguide radiators (OEG) for use from 500 MHz to 2.6 GHz. Other characteristics of this type of radiator important for EM hazard meter calibrations were also determined: near-field corrections, reflection coefficients, and aperture scattering. The suitability of the calibration scheme was tested by performing calibrations at 2 GHz on an EM hazard meter with both a horn radiator and an OEG radiator.

NBSIR 75-819. **Sensitive isotropic antenna with fiber-optic link to a conventional receiver,** E. B. Larsen, J. R. Andrews, and E. E. Baldwin, 108 pages (Sept. 1976). Order from NTIS as PB258554.

Key words: electromagnetic compatibility; fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe.

A broadband, active, isotropic receiving antenna was developed at NBS for the frequency range 15 kHz to 150 MHz. It was designed for use with a conventional receiver to measure weak, near-zone electric fields of unknown polarization, such as leakage emanations from electronic equipment placed within a shielded enclosure. The antenna system consists of three mutually-orthogonal active dipoles, each 31 cm long by 3.5 cm diameter. The entire frequency range of each of the three field components is amplified and used to modulate a high-speed light emitting diode (LED) located inside the dipole. The modulated infrared (IR) signals are guided through glass fibers 10 meters long which connect the "isolated" dipoles to avalanche photodiodes at the far end of the fiber guides. These photodetectors recover the rf modulation from the IR carrier for input to the receiver.

The fiber-optic antenna system described in this paper has high sensitivity (down to 10 μV/m) and fast response time (rf modulations up to 150 MHz). The readout indication at each receiver frequency is proportional to the Hermitian magnitude of E, which is the root-sum-square value of three orthogonal E field components at the measurement point. The linear dynamic range of the antenna system depends on the receiver bandwidth and signal frequency. It is 70 to 75 dB at frequencies between 0.02 and 2 MHz (for 0.5 kHz receiver bandwith), 60 to 70 dB between 2 and 25 MHz (for 5 kHz receiver bandwidth) and 40 to 55 dB between 25 and 200 MHz (for 50 kHz bandwidth).

NBSIR 75-825. **The National Measurement System for cryogenics,** T. M. Flynn, 76 pages (Oct. 1975). Order from NTIS as PB258913.

Key words: cryogenics; data; flowmeter; instrumentation; measurements; National Measurement System.

The Cryogenics Division of NBS has evolved as the nation's central laboratory for cryogenics, much as NBS itself has evolved as the nation's central laboratory with both broad and specific responsibilities. Cryogenic measurement and data outputs provide the common foundation for all the institutions and agencies throughout the nation employing cryogenics to solve their problems.

This Study of the National Measurement System showed that the Cryogenics Division of NBS provides almost every category of measurement and data service that NBS itself provides: not just an instrumentation system (including, for example, pressure, temperature, density, liquid level, flow rate, etc.), but also properties of fluids (both thermodynamic and transport properties); properties of solids (thermal, mechanical and electrical); an interface with the users through systems integration and advisory and consulting services; and a dissemination network through the Cryogenic Data Center.

This study documents the impact, status and trends of the cryogenic measurement system and specifically illustrates these characteristics wherever possible with a specific case study, a recently completed measurements and data program for the flow-metering of liquid nitrogen.

NBSIR 75-827. **Report on NBS dual mixer time difference system (DMTD) built for time-domain measurements associated with**

Phase 1 of GPS, D. W. Allan, 21 pages (Jan. 1976). Order from NTIS as PB247938.

Key words: frequency measurement; frequency mixing; global positioning system; isolation amplifiers; low-noise amplifiers; precision frequency measurements; precision time measurements; time difference measurements; time-domain frequency stability; time interval.

Based on a previous work reported at the 1975 Frequency Control Symposium, the National Bureau of Standards was asked to build a Dual Mixer Time Difference (DMTD) measuring system. This report includes the design, construction, and testing of this DMTD system in fulfillment of this request. The precision of time difference measurement with this system was shown to be about 0.1 picosecond and the accuracy about 10 ps; similarly, the frequency stability precision was shown to be described by $\sigma_y(\tau) \simeq 10^{-13}\,\tau^{-1}$, $0.1\text{s} < \tau < 10^3\text{s}$ and equal to 10^{-16} at τ equal about half a day.

The request for this DMTD system was for measuring the clocks that will go on board the satellites for Phase 1 of the Global Positioning System (GPS) program. The DMTD system described in this report is the only system that can easily meet all of the time-domain measurement requirements for this program.

NBSIR 75-828. **Semi-annual report on materials research in support of superconducting machinery,** R. P. Reed, J. G. Hust, M. B. Kasen, H. M. Ledbetter, D. T. Read, E. R. Naimon, R. E. Schramm, L. L. Sparks, R. L. Tobler, and W. F. Weston, 193 pages (Jan. 1976). Order from NTIS as PB249041.

Key words: composites; copper alloys; cryogenic temperatures; elastic properties; engineering materials; fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity.

Results are reported of a six-month study, March through August 1975, on candidate materials for superconducting machinery. The results cover five areas—advanced composites, elastic properties, fatigue resistance and fracture toughness, magnetothermal conductivity, and thermal conductivity. Material properties were studied over the temperature range 4 to 300 K. Materials studied include: oxygen-free copper; copper-nickel alloys; a precipitation-hardening copper alloy; invar; nickel-chromium-iron alloys; stainless steels; and the composite materials boron/aluminum, boron/epoxy, S-glass/epoxy, graphite/epoxy, and an organic-fiber/epoxy. Some notable results of the study are: the first 4 K fatigue data on a composite material; a ten-fold increase in the fatigue life of a uniaxial glass/epoxy composite between room temperature and liquid-helium temperature; the first 4 K fatigue fracture toughness studies on a nitrogen-strengthened chromium-nickel-manganese steel, which show this material has higher yield strength and adequate toughness compared to conventional stainless steels; room-temperature elastic properties of a copper-cadmium-chromium precipitation-hardening alloy, which are quite different from those of unalloyed copper and show a nonparallel behavior of the shear modulus and the bulk modulus; the thermal conductivity of 304 stainless steel may be reduced one third at 4 K by a 6 MA/m (80 k0e) magnetic field; the first systematic study of the tensile properties of fiber-reinforced composite materials between room temperature and liquid-helium temperature.

This work was supported by the Advanced Research Projects Agency of the U.S. Department of Defense.

NBSIR 75-829. **Radiation characteristics of dipole sources located inside a rectangular, coaxial transmission line,** J. C. Tippet and D. C. Chang, 35 pages (Jan. 1976). Order from NTIS as PB248855.

Key words: EMC measurements; radiation resistance; rectangular coax; shielded strip line; TEM cell.

When making EMC measurements inside a shielded enclosure, the radiation characteristics of the device being tested changes. In this report the change in radiation resistance of dipole sources located inside a National Bureau of Standards TEM transmission cell is determined. In many cases a practical device can be modeled by dipole sources. In these cases, the analysis allows one to predict the device's radiation characteristics in other environments, e.g., free space.

NBSIR 75-900. **Liquid level instrumentation in volume calibration,** R. M. Schoonover, H. H. Ku, J. R. Whetstone, and J. F. Houser, 37 pages (Oct. 1975). Order from NTIS as PB250859.

Key words: density measurement; electromanometer; large volume calibration.

The technique of pressure head measurement for determining liquid levels in tanks has been used for the intercomparison of commercially available electromanometers with themselves and a sight glass. In addition to obtaining intercomparison information, the high precision of these devices coupled with that of volumetric transfer techniques demonstrates the applicability of the calibration method in determining departures of the actual tank geometry from that of a model straight-walled geometry. It is shown that the calibration of the volume-to-height relationship of a 3300 liter tank may be accomplished with an uncertainty in this relationship of ~4 parts in 10,000.

NBSIR 75-902. **A survey of fire accidents involving curtains and draperies—deaths, injuries and financial loss,** L. D. Moore and A. K. Vickers, 35 pages (Dec. 1975). Order from NTIS as PB249539.

Key words: curtains; draperies; FFACTS system; fire; flammable fabrics; NFPA.

A case history survey of 286 fire accidents was conducted. This survey was composed of three groups of case histories in which curtains or draperies (C/Ds) were involved. The cases were analyzed in detail, attempting to ascertain the extent to which these products represented fire hazards.

As none of the three files were chosen on a statistical basis, projection of the data to the overall fire hazard situation is not technically feasible.

To learn more of the physical nature of burning C/Ds, and to supply information that may be utilized to judge the extent of hazard, it is recommended that full-scale experiments be conducted.

NBSIR 75-910. **The role of chemical kinetics in energy conservation,** H. M. Rosenstock, D. Garvin, J. T. Herron, and W. Tsang, 123 pages (Oct. 1975). Order from NTIS as PB248646.

Key words: combustion; data base; energy conservation; estimation schemes; kinetics; modeling; oxidation; pyrolysis.

Many of the technological areas of pertinence to energy independence involve chemical transformation of gas phase materials at high temperatures. The design, control and optimization of such devices and processes have come to depend increasingly on mathematical modeling. Among the most important input data required for these models are information on the detailed chemical mechanisms and the rates of the individual processes. It is concluded that although many resources are available there does not exist at present an adequate, publicly available data base for

the modeling of high temperature systems. A detailed program involving a combination of experimentation and compilation, evaluation and dissemination of gas kinetic data is proposed.

NBSIR 75-913. **Structural test procedures for bicycles,** D. E. Marlowe, 50 pages (Oct. 1975). Order from NTIS as PB248911.

Key words: bicycle; consumer safety; regulations; safety; structural testing.

Tests for several structural performance criteria have been included in a mandatory regulation on bicycle safety which has been proposed by Consumer Product Safety Commission. The apparatus and procedures developed to conduct these tests and results from 15 representative bicycles are described. Several of the bicycles tested failed to meet the requirements for the seat and handlebar stem friction clamp strength.

NBSIR 75-915. **A source of error in paper extract pH determinations: Contact between paper and reference electrodes,** E. J. Parks and R. L. Hebert, 17 pages (Jan. 31, 1975). Order from NTIS as PB249775.

Key words: acidity; contact; decantate; electrode; error; extract; paper; pH; suspension.

If the reference electrode of a pH meter is permitted to contact paper suspended in an aqueous medium, the pH observed is lower than that observed with no contact. The effect has been observed with papers of widely different pH, and varies in magnitude with the proximity of contact and with different papers. The problem can be avoided by taking measurements on decanted equilibrium solutions instead of suspensions of paper.

The cause of this effect may be analogous to the suspension effect in colloidal systems.

NBSIR 75-916. **The role of passive film growth kinetics and properties in stress corrosion and crevice corrosion susceptibility,** J. Kruger, J. R. Ambrose, and T. Kodama, 85 pages (Oct. 1975). Order from NTIS as ADA019648.

Key words: chemical breakdown of passivity; chloride; crevice corrosion; ellipsometry; iron; molybdenum; repassivation kinetics; stress corrosion.

This report consists of four parts as follows: Part I – A study of the influence of molybdate ions on the repassivation kinetics of iron in chloride solutions. Results indicate that molybdate ions precipitated as ferrous molybdate in pits inhibit propagation but not initiation. Part II – Using a technique that allows ellipsometric studies to be made in a crevice, this work has found significantly lower film growth rates in a crevice on iron as compared to the rates observed outside the crevice. Part III – A review of the current state of our understanding of chemical breakdown of passivity is given with a listing of critical questions that remain to be resolved. A short bibliography on the subject is included. Part IV – A review of the qualitative applications of ellipsometry to study localized corrosion that have been developed at NBS is given.

NBSIR 75-918. **Machine-readable mapping from National Network Simulation (NNS) zones to Bureau of Economic Analysis (BEA) areas,** D. W. Lozier and J. R. Stiehler, 77 pages (Sept. 1975). Order from NTIS as PB251412.

Key words: commodity flow analysis; economic analysis; National Network Simulation system.

This report describes the allocation of freight flow data from the National Network Simulation (NNS) zone system to the Bureau of Economic Analysis (BEA) area system. The NNS zone system was developed for use in the analysis of national modal freight flows. The BEA area system was primarily developed for the allocation of national economic data to regions of the United States. The BEA area system contains approximately 175 distinct areas and the NNS zone system, approximately 500. Assuming flows of commodities are known among the NNS zones, the NNS zone to BEA area mapping enables the determination of flows among the BEA areas. When an NNS zone is completely contained in one BEA area, flows entering and leaving the NNS zone accrue entirely to that BEA area. When an NNS zone overlaps more than one BEA area, the mapping specifies the allocation of incoming and outgoing flows among the affected BEA areas. This report presents the NNS zone to BEA area mapping which utilizes 1970 economic data as the basis for allocating flows when an NNS zone overlaps more than one BEA area. It also presents computer programs that could be used to generate a mapping using economic data from some other year. Closely related reports are R. Schofer, "Final Report on the National Network Simulation," NBS Internal Report 75-912 and R.H.F. Jackson, "A National Network Data Base System," NBS Internal Report 75-911.

NBSIR 75-920. **Distribution of water through a vertical plane from automatic sprinkler heads,** R. L. P. Custer and K. Wahle, 48 pages (Dec. 1975). Order from NTIS as PB248913.

Key words: automatic sprinkler; corridor sprinkler systems; discharge patterns; spray distribution; water distribution; water spray.

An investigation was conducted to evaluate the distribution of water through a vertical plane from automatic sprinkler heads as a function of water discharge rate and sprinkler spacing. Tests were conducted to simulate discharging an automatic sprinkler head in a corridor to determine the effectiveness of the sprinkler head in covering a doorway with water spray when positioned at various locations. Major differences in distribution characteristics between sprinkler heads produced by different manufacturers were observed. It was determined that only sprinklers installed on the centerline of the doorway and discharging water at a flow rate of 20 gallons-per-minute or more would cover the top of the doorway.

NBSIR 75-923. **Corrosion of metallic piping on military bases – A survey,** P. W. Brown and J. R. Clifton, 21 pages (Nov. 1975). Order from NTIS as PB250767.

Key words: corrosion; corrosion control; metallic piping; nondestructive evaluation; survey; water hardness.

The results of surveys of the extent of corrosion of metallic piping systems at selected military installations have been analyzed. Potable water, fire protection, heat distribution, cooling, and natural gas distribution systems are included in these surveys. The corrosion evaluation techniques used in these surveys and the types of protection applied are discussed. General recommendations regarding continuation and extension of these surveys are given.

NBSIR 75-924. **Evaluation, revision and application of the NBS stylus/computer system for surface roughness measurement: Minicomputer software,** E. C. Teague, 79 pages (Apr. 1975). Order from NTIS as PB248686.

Key words: amplitude density function; arithmetic average; autocorrelation function; linear least-squares fit; machine language; minicomputer software; surface texture measurement.

A thorough description of all the software used at NBS for characterizing surface texture is given in this report. The description includes flow diagrams and detailed, annotated

listings of machine language programs for step-calibrating the system, for acquiring digitized surface profiles and for calculating from these profiles important parameters and statistical functions. Parameters and functions included are the arithmetic average value, mean square value, average wavelength, average slope, amplitude density function and autocorrelation function.

NBSIR 75-926. **The National Measurement System for length and related dimensional measurements, Part I,** J. W. Lazar and R. L. Bach, 115 pages (Aug. 1976). Order from NTIS as PB257467.

Key words: dimensional; gage; instrument; laser; length; machine; measurements; standard.

The determination of length and related dimensional measurements constitute the largest group of measurements made in science, manufacturing and technology. We have shown that length and related dimensional measurements have impact upon many areas of the economy. We have also shown that the National Measurement System is viable and is adaptable in conforming to the changing requirements of industry. The greater accuracy requirements of some industries brought new measurement techniques into use, e.g., the fringe counting laser interferometer systems now used in many tool rooms and metrology laboratories. We have found no deficiencies in the system but only in individuals or the measurement technique that they use as shown in the comparison measurement on audit packages that were made by the various standards laboratories.

NBSIR 75-927. **The national measurement system for surface finish,** R. D. Young, 51 pages (July 1976). Order from NTIS as PB255809.

Key words: economic factors; measurement; surface; surface finish; surface roughness; technology assessment.

NBS has conducted a study of the National Measurement System for Surface Finish. The proposed system model is discussed including the role of standards committees, instrument manufacturers and measurement users. The economic dimensions of the measurements impact areas and the technological base from which new measurement technology springs is described.

NBSIR 75-929. **A study of the National Force Measurement System,** D. E. Marlowe, 40 pages (June 1975). Order from NTIS as PB261498.

Key words: dynamic force; economic; force; metrication; national measurement system; standards.

A study of the National Force Measurement System has been conducted. The overall structure of the system has been defined, and the size of several of its component elements has been measured. The interactions of many of these components within the system have been assessed. The position which NBS has and the role it plays in the system are better understood as a result of this study.

The best assessment of the condition of the National Force Measurement System is that areas such as static force measurement are fully adequate with the levels of accuracy now provided while other areas such as dynamic force measurements and information transfer, are very inadequate to serve even our present needs.

NBSIR 75-930. **The national measurement system for fluid flow,** W. C. Haight, P. S. Klebanoff, F. W. Ruegg, and G. Kulin, 66 pages (Aug. 1976). Order from NTIS as PB258250.

Key words: aerodynamics; air flow; flow measurement; fluid flow; fluid metering; hydraulics.

Fluid flow is a diverse field concerned with the motion of a wide variety of fluids encountered both in daily life and in scientific applications. It encompasses movement of weather systems by atmospheric winds, travel and dispersion of air pollutants, flow around aircraft and spacecraft bodies, oil and gas pipeline flow, irrigation and waste water flow, and many others. The types of fluid motions encountered in descriptions of these phenomena include closed-conduit, open channel, supersonic, subsonic, steady, unsteady, laminar, and turbulent flow. Measurements of the properties of these flows are instrumental in the functioning of the nation's industries and the advancement of scientific technology, and impact the lives of every consumer.

This report presents the concept of the National Measurement System for Fluid Flow as it exists today and the activities and mechanisms employed within it to generate and implement measurement data. The system structure is presented, and data and information gathered on the interrelationships between the identifiable parts are reported. To further the study, more than 200 contacts were made with trade associations, government agencies, private companies, universities and laboratories.

This study was conducted over the time span June 1973 to December 1975.

NBSIR 75-931. **The National Measurement System for pressure,** P. L. M. Heydemann, 42 pages (Sept. 1976). Order from NTIS as PB261030.

Key words: calibration; calibration chain; pressure; pressure measurement.

The state of the national measurement system for pressure in the range where NBS presently provides calibrations and related services is in a satisfactory state. Needs for expansion of the range have been identified and most of these needs will be satisfied in the near future.

Rapid changes in the needs of the system are generated by the increased use of transducers to transfer measurements and plans are being implemented at NBS to provide all necessary services.

NBSIR 75-932. **The National Measurement System for temperature,** J. F. Schooley, 61 pages (Aug. 1976). Order from NTIS as PB257425.

Key words: data; International Practical Temperature Scale; measurements; National Measurement System; standards; thermometry.

The National Temperature Measurement System reaches quite literally into all phases of American life. Comfort control in home, school, office and factory, health care, manufacturing, food preparation and storage, and all forms of powered transportation are just a few of the many facets of America's human activities that depend for their trouble-free operation on the existence of reliable thermometry.

The Heat Division of the National Bureau of Standards collaborates with the national laboratories of other nations in establishing an International Practical Temperature Scale which represents thermodynamic accuracy insofar as current scientific practice permits. The NBS is the only U.S. agency bearing this responsibility; in addition, only the NBS is responsible for disseminating the International Scale to U.S. scientific and technical activities.

The Study of the National Temperature Measurement System shows that the NBS continues to contribute energetically to the quality of the International Scale. It further indicates that NBS maintains a consistent and deliberate effort not only to provide access to the Scale at the several levels required by U.S. science

and technology, but also to participate in solving special problems in thermometry. These are problems for which the nature of NBS as an objective, expert resource in thermometry uniquely qualifies it to furnish effective, practical solutions.

In briefly describing the many aspects of the National Temperature Measurement System, this Study attempts to portray its great diversity of products, services, and people. The System is largely organized, as might be expected, for the purpose of economic gain; the NBS enters the picture only in those areas where highly accurate or intricate thermometry is essential.

NBSIR 75-933. **A study of the national humidity and moisture measurement system,** A. Wexler, 52 pages (Aug. 1975). Order from NTIS as PB248983.

Key words: humidity; humidity measurement system; measurement of humidity; measurement of moisture; moisture; moisture measurement system; water vapor.

This study analyzes and assesses the status of the National Measurement System for humidity and moisture. It focuses on the physical process of measuring and controlling water vapor and moisture. It describes the nature, extent and economic dimensions of the system. It indicates impacts and trends, identifies deficiencies and shortcomings and shows the role NBS plays in the system. The study presents an overview of the complex structure of interrelated scientific, technological, social and economic components that form the basis of this system.

NBSIR 75-937. **The national measurement system for medical ultrasonics,** P. A. Hudson, 20 pages (Feb. 1976). Order from NTIS as PB265614.

Key words: electroacoustics; medical diagnostics; radiation safety; radiation therapy (ultrasonic); ultrasonics.

The rapid increase in the use of ultrasonics in medical diagnostics has been brought about by recent advances in imaging techniques employing sophisticated electronic systems. Along with the proliferation of this equipment in the medical community has come concern about possible tissue damage due to this type of radiation. Research on damage thresholds is being carried out in laboratories across this country and overseas. Agreement between various researchers is hampered by lack of accurate standards for measurement of transducer beam power and intensity.

The National Measurement System for medical ultrasonics is, at this time, inadequate, fragmented and largely uncoordinated. The Electromagnetics Division is in process of developing standards for measurement of transducer beam power, intensity, and beam pattern. These standards will be disseminated widely throughout the country to provide the needed accuracy and measurement agreement among biomedical researchers and ultimate users (hospitals, physicians, clinics, etc.). Interim standards for beam power were developed 1 1/2 years ago and are already in use by standards laboratories of manufacturers and universities. It is estimated that another 5 years will be required to bring the measurement system under some form of control.

NBSIR 75-942. **The national measurement system for optics,** D. A. Swyt, 63 pages (Aug. 1976). Order from NTIS as PB256644.

Key words: imaging optics; lens testing; microcopy resolution charts; National Measurement System; photographic density; technology assessment.

NBS has conducted a study of the National Measurement System for Optics. The proposed system model is discussed including the role of standards committees, instrument manufacturers and measurement users. The economic dimensions of the measurements impact areas and the technological base from which new measurement technology springs are described.

NBSIR 75-943. **Transactions matrix description of the National System of Physical Measurements,** R. C. Sangster, 91 pages (Aug. 1976). Order from NTIS as PB258914.

Key words: acoustic quantities; electrical quantities; electromagnetic quantities; end-use measurements; ionizing radiation; measurement activities; measurement institutions; mechanical quantities; National Measurement System; optical quantities; thermal quantities; time and frequency.

The interactions among the various elements of the National Measurement System are described in a series of transactions matrices. The National Measurement System consists of all of the activities and mechanisms used by this country to produce measurement data. The transactions matrices describe both the flow of measurement knowledge, goods, and services from suppliers to users in this System, and the activities within a given supplier-user sector. Semiquantitative estimates are made for the magnitude of the transactions, the rate of change of that magnitude, the relative importance or criticality of the transactions, and their adequacy. Basic supplier-user matrices have been developed for the system as a whole and for some 24 different measurement sectors (time and frequency; length and related dimensional measurements; vibration and shock; surface finish; mass, volume and density; force; fluid flow; pressure; temperature; humidity and moisture; thermodynamic properties of fluids; cryogenics; electricity; electromagnetics; medical ultrasonics; acoustics; radiometry and photometry; spectrophotometry; far ultraviolet radiometry; optics; lasers; physical properties of atoms and molecules; surface properties; and ionizing radiation). Some 25 supplier-user sectors have been defined, ranging from technical infrastructural institutions through governmental agencies to a series of commercial-industrial sectors defined by Standard Industrial Classification codes, to the "general public." Combination of like rows or columns from the basic supplier-user matrices for the different measurement sectors has allowed the generation of total input and output matrices for each supplier-user sector.

NBSIR 75-944. **National measurement system for the physical properties of atoms and molecules,** J. W. Cooper, A. V. Phelps, and S. J. Smith, 39 pages (Sept. 1976). Order from NTIS as PB258372.

Key words: atom; energy generation; industrial technology; molecule; primary standards; properties.

National activity in measurement, compilation, evaluation, and dissemination of atomic and molecular data, estimated at 20-25 million dollars annually, impacts directly upon applied research and development projects costing over one-third billion dollars annually. NBS atomic and molecular programs, costing about 3 million dollars annually, provide the basis for the accepted standards for length, time and frequency; provide advanced measurement techniques; set rigorous performance standards for generation of atomic and molecular data, and provide for the construction of a sound data base for the user community. The largest users are programs aimed at energy generation and conversion. Basic sciences of aerodynamics, astrophysics, atmospheric physics and plasma physics are important users. Benefits for a broad range of industrial research activities are potentially large. It is recommended that NBS undertake to ensure the reliability and adequacy of the data base needed for important national programs, expand its contacts with private industry, develop increased awareness of the methodology for ap-

plying atomic and molecular data to technological development, and encourage effective utilization of this sector of the measurement system for the benefit of the economy.

NBSIR 75-947. **Collected executive summaries. Studies of the National Measurement System 1972-75,** R. C. Sangster, 56 pages (Aug. 1976). Order from NTIS as PB258323.

Key words: acoustics; atomic properties; economics; electrical quantities; ionizing radiation; mechanical quantities; national measurement system; optical quantities; surface properties; thermal quantities; time and frequency.

This report contains the Executive Summaries of the reports of the 1972-75 study by the NBS Institute for Basic Standards of the U.S. National Measurement System, which consists of all of the activities and mechanisms which provide physical measurement data required by our society. A series of microstudies focused on specific technical measurement sectors. A macroeconomic study looked at costs of instrumentation and labor for measurement-related activity in our economy. University economists were retained to assist the microstudy authors and to prepare an overall economics report. A central coordinator set a basic pattern for the microstudies, prepared an overall summary report, and generated several documents relating to the system as a whole. Abbreviated titles of the executive summaries are: Final summary report. Direct measurements transactions matrices. Economic analysis. Structure and functions of measurement system. Time and frequency. Length and related dimensional measurements; vibration and shock. Surface finish. Mass, volume and density. Force. Fluid flow. Pressure. Temperature. Humidity and moisture. Thermodynamic properties of fluids. Cryogenics. Electricity. Electromagnetics. Medical ultrasonics. Acoustics. Radiometry and photometry. Spectrophotometry. Far ultraviolet radiometry. Optics. Physical properties of atoms and molecules. Surface properties. Ionizing radiation.

NBSIR 75-950. **Proposed criteria for use of the critical radiant flux test method,** I. A. Benjamin and C. H. Adams, 49 pages (Dec. 1975). Order from NTIS as PB250664.

Key words: fire hazard; fire safety; flooring test; radiant panel.

The objective of this discussion is to present background and other technical data that will help in suggesting criteria to be used in conjunction with the Flooring Radiant Panel Test to determine the potential contribution to fire growth of floor covering systems for use in corridors and exitways.

NBSIR 75-951. **Correlation of floor vibration to human response,** J. R. Shaver, 32 pages (Dec. 1975). Order from NTIS as PB249094.

Key words: analysis; experimental; floor systems; human response; random process; spectral analysis; vibration.

A new approach to the problem of perceptible floor vibrations is presented predicated on the realization that human activity and human response to this activity are random variables. Techniques for data reduction are discussed and a detailed description of one approach is given along with the associated computer program. Data from floor vibrations is compared with current criteria for human response to vibration.

NBSIR 75-952. **An error analysis of failure prediction techniques derived from fracture mechanics,** S. M. Wiederhorn, E. R. Fuller, Jr., J. Mandel, and A. G. Evans, 41 pages (Dec. 1975). Order from NTIS as PB248910.

Key words: crack propagation; error analysis; failure prediction; failure prevention; fracture; statistics; strength.

Three principal methods of failure prediction for brittle materials are analyzed statistically. Each method depends on fracture mechanics for its predictive value and hence, the variance of the failure time is found to depend on the scatter in the fracture mechanics data and the scatter in the estimate of the initial size of the strength limiting crack. The variance is used to calculate confidence limits for the prediction of failure for two materials, glass and silicon carbide. Procedures for the collection and analysis of data are discussed, and the implications of the analysis for lifetime prediction are evaluated.

NBSIR 75-953. **A procedure for determining bicycle braking performance,** D. E. Marlowe, 26 pages (July 1976). Order from NTIS as PB256219.

Key words: bicycles; braking; consumer safety; handbrakes; testing.

A procedure which could be used to determine bicycle braking performance for compliance with the Federal Bicycle Safety Regulation, Requirements for Bicycles, has been developed. The procedure includes tests for brake system integrity and stopping distance performance. Sample data collection sheets and calculations are given.

NBSIR 75-954. **A survey of manufacturers' views on the ETIP procurement experiment. Volume one: Refrigerator-freezers,** P. C. Goodman, 36 pages (Dec. 1975). Order from NTIS as PB253242.

Key words: energy-efficient products; Experimental Technology Incentives Program; life-cycle costing; procurement experiments; refrigerator-freezers.

This report describes the findings of a survey of six refrigerator-freezer manufacturers by the Center for Consumer Product Technology. The survey was conducted for the Experimental Technology Incentives Program (ETIP) as part of its evaluation of a Federal Supply Service (FSS) procurement of refrigerator-freezers. Survey questions were designed to obtain manufacturers' views on the use of Government procurement policies as a means of increasing the rate of introduction of new technologies into the consumer market place. The questions covered the following areas: (1) reasons for participation or nonparticipation of a manufacturer in the ETIP experiment; (2) problems that a manufacturer encountered with existing Federal procurement practices; (3) acceptability of using life-cycle costing in the bidding procedure; and (4) effect of the most recent Government procurement on present and future company operations, including support for engineering and investment in research, types of themes used in advertising campaigns, etc. Results of the survey are reported, and implications are drawn for future ETIP involvement in Government procurement activities.

NBSIR 75-955. **Durability and related tests for selected elements and materials used in the exterior envelope of buildings,** L. W. Masters, E. J. Clark, G. A. Sleater, and A. Hockman, 151 pages (Nov. 1975). Order from NTIS as PB248685.

Key words: aging test; building elements and materials; degradation factors; durability; property measurement test; standard test methods.

This report contains a compendium of state-of-the-art methods to aid in the durability testing of selected elements and materials used in the exterior envelope of buildings. The purposes of the report are to identify currently available property measurement tests and aging tests that can be used for durability testing and to identify the degradation factors included in each aging test. The

report will form the basis for selecting specific elements and materials for inclusion in subsequent comprehensive durability studies. These additional studies are needed because existing short-term methods are seldom fully adequate for predicting long-term performance.

The sources of the methods include the American Society for Testing and Materials (ASTM), the American National Standards Institute (ANSI), building industry trade associations, Federal Specifications and Federal Standards. Indications are made for each test method to show if the methods described include a property measurement test, an aging test or both. If the method contains an aging test, the degradation factors included in the test are listed.

NBSIR 75-957. **Finite element analysis of spotwelded, bonded and weldbonded lap joints,** R. A. Mitchell, R. M. Woolley, and S. M. Baker, 25 pages (Dec. 1975). Order from NTIS as PB250769.

Key words: adhesive-bonded joints; bonded joints; double-lap joint analysis; finite element analysis; joining; joints; single-lap joint analysis; single-lap-joint bending; spotwelded joints; weldbonded joints.

Finite element computer analyses of single-lap and double-lap structural joints are described. A planform analysis articulates the in-plane deformation of the joined sheet material and the lap-shear stresses acting through the spotwelds and/or adhesive. A longitudinal cross-section analysis computes out-of-plane bending effects, particularly important in single-lap joints, and adhesive peel stresses. Numerical results are presented that suggest a reasonable degree of mutual consistency between the planform analysis and the cross section analysis. Although the basic finite element formulation is linear, nonlinear deformation can be simulated by a series of linear solutions. The computer output includes contour plots of stress and strain fields and exaggerated-scale plots of displacements.

NBSIR 75-958. **Simulated precipitation reference materials,** J. K. Taylor, E. R. Deardorff, R. A. Durst, E. J. Maienthal, T. C. Rains, and E. P. Scheide, 25 pages (Oct. 1975). Order from NTIS as PB248743.

Key words: chemical analysis; rainwater analysis; reference materials.

The preparation of a series of reference materials for chemical analysis of natural precipitation is described. The materials consist of ampoules of concentrates which can be diluted to simulate naturally collected samples of rainwater. The analytical measurements made to verify the composition of the samples are also described.

NBSIR 75-960. **The police patrol car: State of the art,** R. G. Massey, 61 pages (Nov. 1975). Order from NTIS as PB249774.

Key words: functional requirements; patrol cars; performance of patrol cars; police patrol cars; problems with patrol cars; state of the art survey.

This report, entitled "The Police Patrol Car: State of the Art" describes the functional requirements of police agencies for patrol cars, the manner in which these requirements are met, or not met, by vehicles currently in use, and a discussion of new automotive technology which might affect patrol car performance in the future.

NBSIR 75-961. **The police patrol car: Economic efficiency in acquisition, operation, and disposition,** R. T. Ruegg, 225 pages (June 1976). Order from NTIS as PB257466.

Key words: fleet management; life cycle costing; patrol cars; police fleets; vehicle leasing; vehicle management.

This study uses the techniques of life cycle costing to analyze some of the decision problems of police fleet management. It addresses the following questions: (1) What are the cost effects of purchasing different sizes of patrol cars and different optional equipment? (2) What are the advantages and disadvantages of direct ownership of vehicles as compared with leasing vehicles? (3) How do the costs of contracting out maintenance compare with costs of an in-house shop? (4) What are the effects of alternative utilization practices on fleet costs? (5) How often should vehicles be replaced? (6) What method of vehicle disposition is most efficient? The techniques used to compare costs of alternative systems are described in a chapter on life cycle costing methodology. Cost estimates and empirical data are presented in the many tables, exhibits, and charts which support the study. Existing fleet practices are described. Findings of the study are expressed as general guidelines for fleet management. The focus of the study is on police patrol cars, but the methods are applicable to other kinds of vehicles.

NBSIR 75-966. **Measurements and observations of the toxicological hazard of fire in a Metrorail interior mock-up,** M. M. Birky, A. W. Coats, S. E. Alderson, J. E. Brown, M. Paabo, and B. Pitt, 20 pages (Feb. 1976). Order from NTIS as PB250768.

Key words: blood; carbon dioxide; carbon monoxide; cyanide; fire; hydrogen chloride; hydrogen cyanide; oxygen; rats.

Oxygen depletion, carbon monoxide, carbon dioxide, hydrogen chloride and hydrogen cyanide were selected for measurement and identification in Metrorail fire tests.

Male rats exposed to the combustion products were examined for changes in blood chemistry, gross pathology and loss of function. Hydrogen cyanide and carbon monoxide levels in blood were elevated and functional changes were noted.

NBSIR 75-967. **Radiative ignition of some typical floor covering materials,** K. D. Braven, 22 pages (Dec. 1975). Order from NTIS as PB251413.

Key words: carpets; floor coverings; horizontal; ignition; ignition time; pilot ignition; radiant heat flux.

The ignition time for some typical floor coverings was measured at varying incident radiant flux levels. A large radiant panel was used as a heat source, with a nonimpinging pilot flame 1.0 cm above the sample as an ignition source. Each material was subjected to flux levels varying from 0.5-2.4 W/cm^2. Samples were 5 cm square, mounted horizontally below the radiant panel. A critical flux level, below which ignition did not occur, was determined for each material. No correlation was observed between the ignition time of flooring samples and the time to flashover in full-scale corridor experiments in which the same flooring materials were used.

NBSIR 75-968. **Selected thermochemical data compatible with the CODATA recommendations,** V. B. Parker, D. D. Wagman, and D. Garvin, 35 pages (Jan. 1976). Order from NTIS as PB250845.

Key words: CODATA compatible values; enthalpies of formation; entropy; Gibbs energy of formation; selected thermodynamic values; thermodynamic properties.

Selected thermochemical properties data at 298.15 K are given for 384 substances. The data are compatible with the current recommendations of the CODATA Task Group on Key Values for Thermodynamics. The set of values provided here is

suitable for use as auxiliary data in evaluations of the thermochemical properties of compounds of the actinide elements. Rules used in the conversion of units and the rounding of numbers are stated.

NBSIR 75-971. **A fire hazard evaluation of the interior of WMATA Metrorail cars,** E. Braun, 34 pages (Dec. 1975). Order from NTIS as PB249776.

Key words: flame spread; flammability; full-scale fire tests; laboratory fire tests; Metrorail cars; neoprene; smoke; transportation; urethane.

A series of fire tests was conducted for the Washington Metropolitan Area Transit Authority to assist them in assessing the potential for fire hazard in the new Metrorail subway cars. Results of small-scale laboratory tests were found inadequate for this assessment. Results of full-scale tests on mock-ups of the interior (and on a real car for a smoke penetration test) show that the potential for hazard arises primarily from the seat padding and covering and from the plastic wall lining. The hazard arises both from smoke development and from spread of flame and heat. The times to reach unacceptable conditions has been determined for several test conditions. It is recommended that the authorities review these times in the context of what they consider to be appropriate times for safe escape. Recommendations are made for increasing the amount of time available for escape. These would require changes in the seating and wall lining materials.

NBSIR 75-972. **Skid resistance measurement tests at the FHWA eastern field test center,** R. W. Kearns and J. F. Ward, 98 pages (July 1976). Order from NTIS as PB259630.

Key words: accident reduction, skidding; correlation, skid resistance; highway safety; pavement, skid resistance; pavement wetting system, tire-pavement interface forces; wet pavement.

The measurement of the skid resistance of highways, under wet weather conditions, is part of the Federal Highway Administration (FHWA) skid accident reduction program. To standardize and to improve the precision of the measurements, the program includes national and regional reference systems to which the highway measuring systems may be systematically related. This report describes evaluation tests conducted at the FHWA Eastern Field Test Center (EFTC) which included the use of the Eastern Area Reference System (EARS) and the Interim Reference System (IRS) maintained by the National Bureau of Standards. The performance characteristics of the EARS, its subsystems and a correlation equation between the EARS and the IRS are presented. A method of quantifying sources of dispersion is applied to the measurements made by the IRS on the EFTC reference surfaces. Recommendations for modifications to the EARS, the test procedures, and EFTC facilities are made.

NBSIR 75-973. **Guide to improving the performance of a manipulator system for nuclear fuel handling through computer controls,** J. M. Evans, Jr., J. S. Albus, A. J. Barbera, R. Rosenthal, and W. B. Truitt, 53 pages (Nov. 1975). Order from NTIS as PB249255.

Key words: computer control of automation systems; computer interface; computer software for robot control; hierarchical control of manipulators; position servos; trajectory control.

The Office of Developmental Automation and Control Technology of the Institute for Computer Sciences and Technology of the National Bureau of Standards provides advising services, standards and guidelines on interface and computer control systems, and performance specifications for the procurement and use of computer controlled manipulators and other computer based automation systems. These outputs help other agencies and industry apply this technology to increase productivity and improve work quality by removing men from hazardous environments.

In FY 74 personnel from the Oak Ridge National Laboratory visited NBS to discuss the feasibility of using computer control techniques to improve the operation of remote control manipulators in nuclear fuel reprocessing. Subsequent discussions led to an agreement for NBS to develop a conceptual design for such a computer control system for the PaR Model 3000 manipulator in the Thorium Uranium Recycle Facility (TURF) at ORNL. This report provides the required analysis and conceptual design. Complete computer programs are included for testing of computer interfaces and for actual robot control in both point-to-point and continuous path modes.

NBSIR 75-974. **The demonstration of experimental lead paint hazard abatement in Atlanta, Georgia,** T. H. Boone, H. W. Berger, A. P. Cramp, and H. A. Jackson, 121 pages (Dec. 1975). Order from NTIS as PB249777.

Key words: abatement; barrier materials; building materials; children; housing; lead-based paint; lead poisoning; paint removal.

This report describes the second stage of an experimental lead paint hazard abatement program carried out in 80 dwelling units in Atlanta, Georgia. The entire program will ultimately involve the abatement of lead paint hazards in a total of approximately 250 dwelling units distributed over three or more cities.

The procedures demonstrated in this field testing program were: paint removal using chemical solvents; paint removal using three heat producing devices; the replacement of components such as windows, doors, and wood trim and the installation of flexible sheet materials, rigid boards, plaster products and aggregate filled coatings, over existing lead paint on walls. Also evaluated was the covering of deteriorated, lead paint coated floors with plywood.

The report includes procedures for inspecting and selecting dwellings for lead paint hazard abatement, evaluations of the suitability and implementation characteristics of the abatement methods, and recommendations for their use.

Subsequent reports will present the results of comparable programs in additional cities and a final report will compare the cost-effectiveness of the alternative abatement methods.

NBSIR 75-975. **The calibration of an optical flat by interferometric comparison to a master optical flat,** C. P. Reeve, 40 pages (Dec. 1975). Order from NTIS as PB253113.

Key words: calibration; diameter; gravitational bending; interferometry; least squares line; linear model; optical flat; profile; standard deviation; uncertainty.

Optical flats are normally calibrated by one of two methods at the National Bureau of Standards. The most frequently used method involves a direct interferometric comparison of a test flat to a master flat. The purpose of this paper is to present a detailed description of this measurement process. Some of the topics discussed are methods of supporting the flats, effects of gravitational bending, measurement of interference fringes, formulation and solution of the linear least squares model, analysis of errors, choice of profile reference line, and graphical display of profiles. An example is worked out in a step-by-step fashion in order to il-

lustrate the process, and a statistical test is incorporated to check whether the process is in control.

NBSIR 75-976. **Standards and measurement capabilities in the Kingdom of Saudi Arabia,** A. A. Bates, 37 pages (Spring 1975). Order from NTIS as PB248986.

Key words: building codes; industrialization; less-developed country; SASO; Saudi Arabia; standardization; tentative standards.

The Saudi Arabian Standards Organization (SASO) is operating under uniquely difficult circumstances. Basic sources of difficulties are: (1) almost total lack of any industries for consultation and cooperation, (2) extreme speed at which Saudi Arabia is attempting transformation into an urban-industrial state, (3) unavailability of well-trained indigenous Saudi personnel, either scientific-technical or secretarial-clerical, and (4) lack of SASO laboratory facilities for standardization research work.

Operating procedures which SASO has adopted are based on consensus principles utilized in countries with advanced industrial economies. Such procedures are not now applicable in Saudi Arabia. Only the Saudi Portland Cement industry now offers opportunity for consensus standardization.

Until industrialization has advanced in the Kingdom, SASO should use Interim Procedures to produce Tentative Standards for national use. The Interim Procedures should permit direct and immediate adoption of necessary standards from reliable national and international sources with minimum modification. The nature and terms of use of Tentative Standards must be defined for public understanding.

SASO should not play the central role in the enforcement of SASO standards. SASO should have an advisory relationship with authorities charged with mandatory standards enforcement. SASO should not now undertake the development of a national Saudi building code, although it must produce the standards upon which a building code may be promulgated by a related agency appointed for that purpose.

NBSIR 75-977. **Development of solid state samplers for work atmospheres: Phosphine,** B. Greifer and J. K. Taylor, 32 pages (Jan. 1976). Order from NTIS as PB251220.

Key words: air analysis; air sampling; gas analysis; industrial hygiene; phosphine; sorber; work atmosphere.

Investigations to find suitable solid-state sorber materials for phosphine in work atmospheres at the ppm level are described. The best sorber to date is silver nitrate-impregnated silica gel. Some difficulties remain to be overcome before a procedure for determining the amount of phosphine adsorbed can be recommended.

NBSIR 76-833. **A precision 30 MHz waveguide-below-cutoff attenuator with an absolute electronic readout, NBS model XII,** R. T. Adair, 50 pages (Jan. 1976). Order from NTIS as PB250846.

Key words: absolute (unambiguous) readout; piston; precision attenuator; sensor; waveguide-below-cutoff.

A coaxial precision waveguide-below-cutoff attenuator is described which utilizes an absolute (unambiguous) electronic digital readout of displacement in decibels instead of the usual gear-driven mechanical counter/dial readout in decibels. The attenuator has a fixed-position rf input connector and a movable rf output connector. The attenuation rate for 30 MHz operation is given along with a discussion of sources of errors. In addition, information is included to aid the user in making adjustments on the attenuator should it be damaged or disassembled for any reason.

NBSIR 76-834. **A system for inflating a balloon using helium stored in the liquid phase,** C. F. Sindt and W. R. Parrish, 38 pages (Jan. 1976). Order from NTIS as PB250666.

Key words: balloon; cryogenic balloon inflation; heat transfer; liquid helium; packed bed heat exchangers.

This report covers the design and development of the prototype of a system to be used to fill a balloon that has been launched from an aircraft. The described system uses a hot packed bed heat exchanger to gasify 45.4 kg of liquid helium and warm the gas to 260 K for filling the balloon. The prototype system was successfully demonstrated on the ground by filling an ambient pressure balloon with 300 m^3 of helium gas at an average temperature of 260 K in six minutes and 45 seconds.

NBSIR 76-836. **Low temperature fracture behavior of a Ti-6Al-4V alloy and its electron beam welds,** R. L. Tobler, 49 pages (Apr. 1976). Order from NTIS as PB254459.

Key words: electron beam welding; fatigue; fracture toughness; low temperature tests; mechanical properties; titanium alloy.

The effects of electron beam (EB) welding on the fracture behavior of a recrystallization annealed, extra-low-interstitial Ti-6Al-4V alloy have been investigated at temperatures in the ambient-to-cryogenic range. Plane strain fracture toughness (K_{Ic}) and subcritical crack growth parameters were measured using compact specimens 10 to 25.4 mm-thick. These parameters can be used to predict the safe operating lifetimes of cryogenic pressure vessels and other welded Ti-6Al-4V structures.

Although EB welding transforms the base metal microstructure extensively, its effects on the material's fatigue crack propagation resistance at intermediate stress intensity factors are negligible. The growth rates, da/dN, of fatigue cracks sited in the fusion and heat-affected zones of weldments were temperature insensitive and nearly equivalent to rates for the base metal. However, welding introduces a zone of low fracture toughness at the heat-affected-zone/fusion-zone boundary. The K_{Ic} value for this boundary zone at liquid nitrogen temperature (76 K) was 45 $MN/m^{3/2}$, 16 percent lower than the base metal. The base metal fracture toughness increases between 4 and 295 K, with an abrupt transition to higher K_{Ic} values occurring at temperatures between 76 and 125 K. Static load cracking, temperature effects, and specimen orientation effects on the fracture behavior of this titanium alloy are central topics of discussion.

NBSIR 76-837. **Characterization of a superconducting coil composite and its components,** A. F. Clark, W. F. Weston, V. D. Arp, J. G. Hust, and R. J. Trapani, 143 pages (July 1976). Order from NTIS as PB261709.

Key words: fiberglass cloth; mechanical properties; stress analysis; superconducting coil composite; superconducting wire; thermal properties.

The physical properties of a superconducting coil composite and its components are studied in order to accurately predict the coil behavior under a variety of operating conditions. This second interim report includes data on the Young's moduli, the Poisson's ratios, the shear moduli, and the thermal conductivity of the coil composite as well as the compressive modulus of the fiberglass cloth and the thermal expansion of the superconducting wire. In addition, the development of an acoustic technique for the determination of the elastic moduli of the coil composite and the stress analysis of transversely isotropic magnet coils are reported.

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NBSIR 76-839. **Semi-annual report on materials research in support of superconducting machinery,** R. P. Reed, J. G. Hust, M. B. Kasen, H. M. Ledbetter, D. T. Read, R. E. Schramm, L. L. Sparks, and R. L. Tobler, 155 pages (Apr. 1976). Order from NTIS as PB252013.

Key words: aluminum alloys; composites; cryogenic temperatures; elastic properties; engineering materials; fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity.

Results are reported of a six-month study, ending March 1976, on candidate materials for superconducting machinery. The results cover five areas—advanced composites, elastic properties, fatigue resistance and fracture toughness, magnetothermal conductivity, and thermal conductivity. Material properties were studied over the temperature range 4 to 300 K. Materials studied include: aluminum alloys 1100, 2014, 2219; a nickel-chromium-iron alloy; iron-47.5 nickel; and the composite materials boron/aluminum, boron/epoxy, *S*-glass/epoxy; graphite epoxy. Some notable results of the study are: First reports of compressive mechanical testing on composite materials at 4 K; regular temperature behavior of the elastic constants of aluminum 2014 and 2219 and of iron-47.5 nickel, which is magnetic; none of the mechanical properties of the nickel-chromium-iron alloy tested were affected deleteriously by cryogenic temperatures; in aluminum alloy 2219, J_{Ic} and K_{Ic} are not equivalent because of subcritical crack extension; both electrical and thermal conductivities of aluminum alloy 1100 are reduced by magnetic fields.

NBSIR 76-840. **FM-CW electromagnetic technique of measuring coal layer thickness,** D. A. Ellerbruch and D. R. Belsher, 38 pages (May 1976). Order from NTIS as PB258324.

Key words: automation; coal; coal mine safety; dielectric constant; energy; microwave measurement; nondestructive testing; thickness of coal layer.

An FM-CW microwave system was investigated for measuring coal layer thickness. Measurements were made in three different mines near Pittsburgh, Pa., near Fairview, W. Va., and near Coffeen, Ill. Microwave frequencies in the range 1-2 GHz were used to measure samples up to 55 cm thick. All samples were backed with a naturally occurring shale. Measurements were also made on coal and shale samples compounded in the laboratory at the Bureau of Mines Pittsburgh Mining and Safety Research Center near Bruceton, Pa.

The results indicate that layer thickness can be determined in most cases, although large anomalies may, in some cases, produce misleading results. Many anomalies that were detected with the FM-CW system were verified visually by drilling into the coal layer.

The dielectric constant of coal apparently varies significantly within a coal seam.

The form of the output signals from the FM-CW system seem to simplify the data interpretation and analysis process as compared to the manually swept microwave system used previously. It appears that this technique has the potential of measuring changes in the dielectric constant of a coal seam and providing an output that can be used for real-time corrections in layer thickness measurement.

NBSIR 76-841. **An analytical and experimental determination of the cutoff frequencies of higher-order TE modes in a TEM cell,** J. C. Tippet, D. C. Chang, and M. L. Crawford, 27 pages (June 1976). Order from NTIS as PB256319.

Key words: shielded strip line; TEM cell.

In addition to the TEM mode, higher order TE and TM modes can propagate in a TEM cell. Since only the TEM mode is desired, the higher-order modes restrict the useful frequency range of the TEM cell. In this paper, the cutoff frequency of the first higher-order mode is obtained both analytically and experimentally for several TEM cells of differing geometry. The difference between the experimental and theoretical results is shown to be only a few percent. In addition the field distribution of the first higher-order mode is found explicitly.

NBSIR 76-842. **Error equations used in the NBS precision G/T measurement system,** W. C. Daywitt, 21 pages (Sept. 1976). Order from NTIS as PB258331.

Key words: error analysis; G/T; precision measurements; radio star; satellite communications.

Equations presently being used in the precision NBS G/T measurement system are presented in this report. Included are the assumptions upon which these equations are based and sample calculations showing how the measurement errors vary with antenna elevation angle.

NBSIR 76-844. **A microwave vector voltmeter system,** K. C. Roe and C. A. Hoer, 70 pages (Aug. 1976). Order from NTIS as PB264300.

Key words: amplitude; computer controlled; diode detectors; microwave measurements; phase angle; self-calibration; seven-port junction; vector voltmeter.

This report presents a system description and operating procedure for a vector voltmeter system which covers the frequency range .5 to 12 GHz. The design is based upon a seven-port junction where phase and amplitude information is obtained using only power detectors. The system is computer controlled and self-calibrating for ratio measurements.

NBSIR 76-846. **An NBS phase noise measurement system built for frequency domain measurements associated with the Global Positioning System,** S. R. Stein, 30 pages (Aug. 1976). Order from NTIS as PB258327.

Key words: Global Positioning System; phase-locked loop; phase noise measurement system; spectral density of phase.

A self-contained system is described which was constructed to perform phase noise measurements for the first phase of the Global Positioning System (GPS). It is capable of evaluating a pair of similar oscillators or a single oscillator and a frequency synthesizer using the phase-lock technique. Three features have been included to simplify the operation of the instrument: internal circuitry automatically detects an out-of-lock condition; an optimized second order phase-lock loop reduces phase error by a factor of 10^5 over a first order loop; selection of operating mode is made by a single front panel switch.

NBSIR 76-848. **Semi-annual report on materials research in support of superconducting machinery,** R. P. Reed, J. G. Hust, M. B. Kasen, H. M. Ledbetter, H. I. McHenry, D. T. Read, R. E. Schramm, L. L. Sparks, and R. L. Tobler, 322 pages (Oct. 1976). Order from NTIS as PB261996.

Key words: aluminum alloys; composites; elastic properties; engineering materials; fatigue; fracture; iron alloys; cryogenic mperatures; maraging steels; mechanical properties; nickel alloys; phenolformaldehyde; stainless steels; superconducting machinery; thermal conductivity; titanium alloys.

Results are reported of a six-month study, ending September 1976, on candidate materials for superconducting-machinery

components. The results cover five areas—advanced composites, elastic properties, fatigue resistance and fracture toughness, magnetothermal conductivity, and thermal conductivity. Material properties were studied over the temperature range 4 to 300 K. Materials studied include: aluminum alloy 5083, copper-0.3, cadmium-0.3 tin, copper-28 nickel, iron-48 nickel, 3.5 Ni and 9 Ni steels, titanium-4 aluminum-6 vanadium, titanium-5 aluminum-2.5 tin, stainless steel 21-6-9, several austenitic stainless steels of the 300 series, 300-grade maraging steel, phenolformaldehyde, and the composites boron/aluminum, boron/epoxy, graphite/epoxy, and niobium-titanium/copper. Some notable results of the study are: anomalous elastic properties of stainless steel 21-6-9 due to a Néel transition; complete sets of elastic constants for two composties, B/Al and NbTi/Cu; thermal conductivities of Ti-6Al-4V and Fe-48Ni are reduced by a magnetic field while those of Cu-0.5 Sn and Cu-28Ni are unaffected; a screening method for composites of possible cryogenic use; general trends regarding temperature effects on the fracture toughness and fatigue-crack-growth resistances of structural alloys are correlated with crystal structure class; and the tensile-yield-strength and fracture-toughness data for fourteen commercial structural alloys at 4 K and 295 K are compared demonstrating an inverse relationship between these properties and indicating the optimum combination of properties that are technologically possible. Also, the materials and properties studied experimentally during the three-year program are summarized. This work was supported by the Advanced Research Projects Agency of the U.S. Department of Defense.

NBSIR 76-979. **Intercomparison procedures for gage blocks using electromechanical comparators,** J. S. Beers and C. D. Tucker, 23 pages (Jan. 1976). Order from NTIS as PB248992.

Key words: calibration; comparator; gage blocks; length; measurement process.

The widely used procedures for calibrating gage blocks by comparison with blocks of known length generally lack the redundancy needed to evaluate measurement uncertainty or the controls needed to monitor the process on a continuing basis. A detailed description is given here for the systematized intercomparison of groups of four nominally equal gage blocks using an electromechanical comparator. Two of the blocks are unknowns and two are standards. The process provides the redundancy needed for evaluating uncertainty and for continuous monitoring. Gage block thermal effects, equalization time, handling techniques, and observation sequence are described.

NBSIR 76-980. **NBS space processing research,** E. Passaglia and R. L. Parker, 217 pages (Feb. 1976). Order from NTIS as PB250849.

Key words: convection; crystal growth; crystal perfection; microgravity; purification; space processing.

This report describes NBS work for NASA in support of NASA's Space Processing Program covering the period November 1, 1974 to December 31, 1975. The objectives of the NBS program are to perform ground-based studies (and, where appropriate, space-based studies) of those aspects of space that could possibly provide a unique environment for making materials more perfect or more pure. The approach taken deals primarily with experimental and theoretical studies of the possible effects of the absence of gravitational forces on those materials preparation processes where the presence of gravity may be important in reducing perfection or purity. The materials preparation processes studied comprise six tasks in the areas of crystal growth, purification and chemical processing, and the preparation of composites.

NBSIR 76-982. **Data processing and data analysis procedures for fire load and live load survey program,** R. M. McCabe, C. Culver, L. T. Lee, and J. G. Hirschberg, 344 pages (Dec. 1975). Order from NTIS as PB248699.

Key words: buildings; computers; data processing; fire loads; load surveys.

Data collection and data processing procedures utilized in connection with a nationwide fire load and live load survey program are described. The techniques developed for transferring the field survey data to a form suitable for computer processing are discussed. Procedures adopted for data analysis are included. Documentation of the computer programs developed for this purpose is also presented.

NBSIR 76-983. **A survey of manufacturers' views on the ETIP procurement experiment. Volume two: Water heaters,** P. C. Goodman, 34 pages (Jan. 1976). Order from NTIS as PB251213.

Key words: energy-efficient products; Experimental Technology Incentives Program; life-cycle costing; procurement experiments; water heaters.

This report describes the findings of a survey of seven water heater manufacturers by the Center for Consumer Product Technology. The survey was conducted for the Experimental Technology Incentives Program (ETIP) as part of its evaluation of the Federal Supply Service (FSS) procurement of water heaters. Survey questions were designed to obtain manufacturers' views on the use of Government procurement policies as a means of increasing the rate of introduction of new technologies into the consumer marketplace. The questions covered the following areas: (1) reasons for participation or nonparticipation of a manufacturer in the ETIP experiment; (2) problems that a manufacturer encounters with existing Federal procurement practices; (3) acceptability of using life-cycle costing in the bidding procedure; and (4) effect of the most recent Government procurement on present and future company operations, including support for engineering and investment in research, types of themes used in advertising campaigns, etc. Results of the survey are reported, and implications are drawn for future ETIP involvement in Government procurement activities.

NBSIR 76-984. **Improved ultrasonic standard reference blocks,** G. F. Sushinsky, D. G. Eitzen, D. J. Chwirut, C. J. Bechtoldt, and A. W. Ruff, 129 pages (Nov. 1976). Order from NTIS as PB262020.

Key words: aluminum ultrasonic standards; ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; metallurgical variables; nondestructive evaluation; pulse echo; steel ultrasonic standards; titanium ultrasonic standards; ultrasonics.

A program to improve the quality, reproducibility and reliability of nondestructive testing through the development of an improved ASTM-type ultrasonic reference standards system is described. Reference blocks of aluminum, steel, and titanium alloys are considered. Equipment representing the state-of-the-art in laboratory and field ultrasonic equipment was obtained and evaluated. RF and spectral data on twenty-two sets of ultrasonic reference blocks were taken as part of a task to quantify the variability in response from nominally identical blocks. Techniques for residual stress, preferred orientation, and microstructural measurements were refined and applied to reference blocks rejected by manufacturers during fabrication in order to evaluate the effect of metallurgical condition on block response. The effects of certain dimensional variables on block response

were studied and new fabrication techniques considered. A study of the effects of measurement system variables on block response was carried out. A calibration service for ASTM E127-type reference blocks has been established and the development of a loaner service for calibration blocks is underway.

NBSIR 76-985. **A computer model to determine low cost techniques to comply with the Privacy Act of 1974,** R. C. Goldstein and H. H. Seward, 57 pages (Feb. 1976). Order from NTIS as PB250755.

Key words: computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs.

This document contains a complete description of the steps necessary to run the Cost of Privacy Model along with a description of the computer program which implements the Model. This document describes the general system requirements for running the program, how to input information to the Model and how to interpret the output.

The Model, which was developed for the National Bureau of Standards by the D.P. Management Corporation of Lexington, Mass., accepts inputs about personal data systems, utilizes algorithms to provide incremental resources required to comply with the Privacy Act of 1974, and applies cost factors to the resources to provide a cost estimate. Cost estimates of alternative compliance techniques can be generated. These can later be compared by the user to determine a cost effective method of compliance.

NBSIR 76-986. **Building energy authority and regulations survey: State activity,** R. M. Eisenhard, 52 pages (Jan. 1976). Order from NTIS as PB250858.

Key words: authority; building; energy; legislation; regulations; state.

This report provides the status of State authority to regulate energy use in new buildings and the status of bills creating such authority that were pending in the 1975 legislative session. Regulations that have been developed are identified and described. Legislation relating to solar energy, retrofitting, insulation and other building energy matters, is identified and the status indicated.

NBSIR 76-987. **Effect of insulation on the surface temperature of roof membranes,** W. J. Rossiter, Jr. and R. G. Mathey, 20 pages (Feb. 1976). Order from NTIS as PB250857.

Key words: built-up roofing; insulation; performance; radiative cooling; roofing; solar heating; surface temperature.

The surface temperatures of black, gray and white roofs were calculated for various thicknesses of insulation located between the membrane and roof deck. The calculations were performed using a steady-state heat balance equation to illustrate the increase in roof surface temperatures due to solar radiation.

The calculations indicate that the first increment, about 1 inch (25 mm), of insulation causes a significant rise in the roof surface temperature due to solar radiation. Increasing the amount of insulation above this first increment to greater thicknesses does not appreciably increase the roof surface temperature.

NBSIR 76-988. **Regional seminar on a system of standardization and metrology for Latin America,** H. S. Peiser and R. S. Marvin, Eds., 100 pages (Feb. 1976). Order from NTIS as PB254469.

Key words: AID; assistance; certification programs; education of metrologists; industrializing nations; LDC's; metrology.

This report contains the papers presented at the first of a series of Regional Seminars, organized under the technical guidance of NBS and sponsored by the U.S. Agency for International Development and the Direccion General de Normas y Tecnologia of Bolivia. The Seminar was held at La Paz on the 24th and 25th of June, 1974, with participants from Bolivia, Brazil, Chile, Ecuador, Korea, Peru, Turkey, Thailand, and the United States of America. The Seminar was organized into four sessions, each of one-half day duration, covering: Session I, "Interactions for Information"; Session II, "Interactions for Standards"; Session III, "Interactions for Solutions to Technical Problems"; and Session IV, "Interaction for Training."

NBSIR 76-990. **Report of fire tests on eight TGS semiconductor gas sensor residential fire/smoke detectors,** R. G. Bright, 17 pages (Apr. 1976). Order from NTIS as PB251769.

Key words: detectors; fire detectors; gas detectors; smoke detectors; Taguchi gas sensors.

At the request of the Bureau of Engineering Sciences Consumer Product Safety Commission, twenty-four Taguchi gas sensor (TGS) detectors, representing eight manufacturers were tested to the requirements of Section 22 (base sensitivity tests) and Section 24 (full-scale fire tests) of Underwriters' Laboratories Standard No. 217, "Standard for Single and Multiple Station Smoke Detectors." Two conventional single-station smoke detectors, one an ionization chamber type and the other a photoelectric type, were included in the test series for comparison. Only one of the TGS detectors was able to meet the requirements of Section 22, base sensitivity tests. None of the TGS detectors were able to meet the requirements of Section 24, full-scale fire tests. The two conventional smoke detectors met the requirements of Section 22 and 24.

NBSIR 76-991. **Evaluation of transparent electro-photographic film and camera system,** T. C. Bagg, 8 pages (Jan. 1976). Order from NTIS as ADA021255.

Key words: add-on films; information storage; microforms; transparent electrophotographic material.

On behalf of the Naval Supply Systems Command, the National Bureau of Standards was requested to assist in the evaluation of new microfilm techniques and materials which permit the adding-on of images at various times. This is an interim report on the initial evaluation of the AB Dick/Scott System 200 which uses transparent electrophotographic materials.

NBSIR 76-992. **Studies of deformation at sliding wear tracks in iron,** A. W. Ruff, 70 pages (Feb. 1976). Order from NTIS as ADA021295.

Key words: electron channeling; iron; metals; plastic deformation; surfaces; wear.

Determinations of strains have been made on the surface and subsurface on specimens of high purity iron after different amounts of sliding wear have taken place. The method involved the measurement of loss of intensity (contrast) of particular electron channeling lines obtained from small selected areas near the wear track. Through the use of a calibration specimen deformed plastically to a range of strain values, the channeling line contrast loss was related to plastic strain. Strain maps lateral to the wear track and below the original surface were obtained for different total sliding distances by removing controlled thicknesses of iron using electropolishing. In all cases the maximum strain was found at the track center location at the surface and the strains

decreased steadily with depth below the track. At 50 g load the strains vanished at about 40 μm depth. Significant strains were found to exist outside the wear track boundaries. The results are compared with other studies previously reported. There was no indication of a soft or less hardened surface layer in any of the specimens studied.

NBSIR 76-993. **The calibration of a pentaprism,** C. P. Reeve and R. C. Veale, 33 pages (Jan. 1976). Order from NTIS as PB253227.

Key words: autocollimator; calibration; constant deviation prism; geometrical model; optical square; pentaprism; reflection; refraction; standard deviation; uncertainty.

A pentaprism, or optical square, is one of a class of objects known as "constant deviation prisms" whose purpose is to bend a beam of light exactly 90° regardless of the angle of incidence of the light. It is used in many optical measurements where the line of sight or a beam of light must be turned at a right angle. The calibration process which is described is fairly simple and requires two mirrors, two autocollimators, and a surface plate. Consideration is given to the effects of small angular errors in both the internal geometry of the pentaprism and the positioning of the pentaprism relative to an autocollimator. An example of the calibration of the important pentaprism parameters is given. A simple statistical test is employed for testing whether the measurement system is in control.

NBSIR 76-996. **Testing for the impact resistance of ophthalmic lenses,** R. E. Berger, 34 pages (Mar. 1976). Order from NTIS as PB251998.

Key words: drop ball test; impact resistance; ophthalmic lens; proof testing; research associate program; sampling test.

The principal findings of the Optical Manufacturers Association's Research Associate Program are summarized. The limitations of the present drop ball test for impact resistance are discussed. Essentially, only a small part of the lens surface and a small part of the edge are subjected to sufficiently high stresses. It is therefore desirable to replace the drop ball test with a sampling procedure from which meaningful information on lens quality can be obtained. Some aspects of the design of a sampling plan, in which the overall quality of a laboratory's lenses is monitored by periodically testing a set of coupon lenses, are discussed.

NBSIR 76-997. **Proceedings of procurement practices symposium—Health care, October 14-16, 1975,** J. G. Berke, Ed., 82 pages (Feb. 1976). Order from NTIS as PB254298.

Key words: certification programs; ETIP; incentives; innovation; life cycle costing; medical products and standards; procurement policies; product testing; specifications; unsolicited proposals; VA.

The general objectives of the conference were to investigate ways for improving interaction between health care personnel and the manufacturers of hospital products and systems, so that the demands of all hospitals for improved and innovative products and systems can be more adequately met; to explore various means available for encouraging innovation and more efficient technological change: from initial research, through product development, user testing and evaluation, marketing and purchasing, to post-delivery assistance for the using services; to develop approaches that will permit hospitals to acquire the latest technologies more expeditiously and economically through the procurement process. Workshops were organized to consider procurement mechanisms, information interchange, testing and evaluation of medical products, and the interrelationship between marketing, R&D and procurement. Workshops were grouped as follows: (1) Interaction Between the Hospital User and the Industry Supplier, (2) Research and Development for Innovative Products, (3) Product Testing and Evaluation, (4) Specifications, (5) Post Delivery Performance, Warranties and Training by Vendors, (6) Cost Saving and Quality Improvement Through Innovative Products.

NBSIR 76-998. **Development of a solid sorption tube and analytical procedure for hydrogen cyanide in the workplace atmosphere,** B. C. Cadoff and J. K. Taylor, 25 pages (Apr. 1976). Order from NTIS as PB253228.

Key words: air analysis; air sampling; gas analysis; hydrogen cyanide; industrial hygiene; ion selective electrode; sodium hydroxide; work atmosphere.

The development of a sampling tube for collecting HCN in the workplace atmosphere is described. The tube contains 4.0 g of flake NaOH and can be readily fabricated in the laboratory. Details are given concerning the construction and use of the tube and data is presented on collection of HCN at levels of five times the TLV, one fifth the TLV, and at the TLV. Analysis of the tube contents using the cyanide ion selective electrode is described. This method is simple, rapid, and relatively free of interferences. Data on the analyses of tubes containing cyanide is described and estimates of the precision and accuracy of the method are given.

NBSIR 76-1000. **The construction, operation and performance of a reactive gas generator; with specific application to HCHO, CH_3CHO, CH_2CHCHO, SO_2, HCN and HCl production,** J. A. Walker and W. Tsang, 55 pages (Jan. 1976). Order from NTIS as PB251219.

Key words: acetaldehyde; acrolein; formaldehyde; gas chromatography; hydrogen chloride; hydrogen cyanide; pollution; pyrolysis; reactive gas generator; sulfur dioxide.

An instrument capable of generating a variety of reactive gases in trace levels has been constructed and tested. Operational details, with specific application to HCHO, CH_3CHO, CH_2CHCHO, SO_2, HCN and HCl production are discussed.

NBSIR 76-1002. **Industrial process data for fluids: A survey of current research at the National Bureau of Standards,** H. J. White, Jr., Editor, 55 pages (Apr. 1976). Order from NTIS as PB257469.

Key words: industrial process data; project summaries; quantitative numerical data.

This report summarizes current activities sponsored by three groups within the National Bureau of Standards that are involved with the production of industrial process data for fluids. The three groups involved are the Cryogenics Division, the Equation of State Section of the Heat Division, and the Office of Standard Reference Data; other organizations in NBS and outside are also involved in various ways. The report takes the form of a listing of projects with some detailed information about each. Some of the projects are designed to provide industrial process data directly. Others systematically cover types of data that are of continual utility in industrial process calculations with the result that the data produced will be used for industrial purposes as well as for other purposes. A few of the projects attack problem areas that must be resolved before proper industrial process data in the area can be obtained. All of the projects focus on quantitative numerical data obtained for direct measurement, critical evaluation of data from the literature or theoretical estimation or calculation. This report has been prepared to show in-

terested readers the interrelationships within a set of projects that might otherwise pass unnoticed because different organizational units within NBS are involved. Continued interaction between the program managers involved leads to interactions between the projects so that the listing is not a listing of independent unreacting projects but rather a listing of interacting projects following broad programmatic lines.

NBSIR 76-1003. **Thermal conductivity and electrical resistivity of six copper-base alloys,** M. C. I. Siu, W. L. Carroll, and T. W. Watson, 22 pages (Mar. 1976). Order from NTIS as PB251211.

Key words: copper-base alloy properties; electrical resistivity; Smith-Palmer equation; thermal conductivity.

Measurements of the thermal conductivity, λ, and electrical resistivity, ρ, of oxygen free copper and six copper-base alloys in the temperature range 298 to 924 K are presented. Except for copper, the λ and ρ values of copper alloys having the same chemical composition as those given in this paper have not been previously reported. The measured values of $\lambda(W \cdot m^{-1} \cdot K^{-1})$ and $\rho(\Omega \cdot m)$ were found to conform, within 10 percent, to the predictions of the Smith-Palmer equation, $\lambda = 2.39 \times 10^{-8}\ T/\rho + 7.50$ $[W \cdot m^{-1} \cdot K^{-1}]$, where T is the thermodynamic temperature expressed in kelvins.

NBSIR 76-1007. **Psychological deterrents to nuclear theft: A preliminary literature review and bibliography,** P. G. Meguire and J. J. Kramer, 51 pages (Mar. 1976). Order from NTIS as PB252021.

Key words: behavioral impact; cognitive processes; nuclear weapon theft; perceptual processes; psychological deterrence; security systems; sensory processes; threat analysis.

A review of the *unclassified* literature dealing with psychological deterrents was conducted for the Defense Nuclear Agency (DNA). Its purpose was to identify techniques that might be useful in DNA's Forced-Entry Deterrent Systems (FEDS) Program for psychologically deterring nuclear weapon theft. The review indicates that while human psychological processes (sensory, perceptual, and cognitive) can be manipulated by various means, definitive empirical data are lacking which *directly* relate to deterring nuclear weapon theft. Behavioral impact research should be undertaken by DNA to (1) ascertain the deterrence values of the many techniques identified and (2) test the hypotheses implicit in the FEDS concept.

NBSIR 76-1008. **Energy conservation through the facilitation of increased blended cement use,** P. W. Brown, J. R. Clifton, and G. Frohnsdorff, 28 pages (Feb. 1976). Order from NTIS as PB251218.

Key words: blast furnace slag; blended cements; energy conservation; fly ash.

About 95 percent of the cement produced in the United States is portland cement and its manufacture requires about 2 percent of the energy consumed annually in the nation's industrial processes. The production of blended cements containing substantial amounts of fly ash or blast furnace slag and their substitution for portland cement appears attractive from the standpoint of energy conservation. While production and utilization of blended cements in other industrialized countries is extensive, blended cements account for less than 1 percent of the total cement production in the U.S. The reasons for the small U.S. production of blended cements are discussed in the contexts of standards revision and the need for the development of additional data as a basis for this revision.

NBSIR 76-1010. **Optical materials characterization,** A. Feldman, D. Horowitz, R. M. Waxler, I. H. Malitson, and M. J. Dodge, 27 pages (Feb. 1976). Order from NTIS as PB250654.

Key words: birefringence; elastooptic constants; infrared-laser window materials; interferometry; KCl; photoelasticity; piezo-optic constants; refractive index; stress-optical constants; thermal coefficient of refractive index.

Refractive index and the photoelastic constants have been measured on specimens of reactive atmosphere processed (RAP) KCl and KCl nominally doped with 1 percent KI. The refractive indices were measured by the minimum deviation method in the wavelength range 0.25 μm to 15.5 μm. Measurements were made near 20 and near 34 °C on the RAP specimen and near 20 °C on the doped specimen. Each set of experimental data was fitted to a three term Sellmeier-type dispersion equation. The temperature coefficient of index was then computed for the RAP KCl. The data for the different types of KCl were compared to each other and to earlier reported data on commercial KCl. The piezo-optical constants q_{11}, q_{12} and q_{44} and the elasto-optical constants p_{11}, p_{12} and p_{44} were obtained at 10.6 μm for the RAP and doped KCl. The measurements required the use of a modified Twyman-Green interferometer capable of measuring fringe shifts ~0.002 of a wave. Within experimental error the coefficients of the two materials agree. Negligible dispersion was found for q_{11}, q_{12}, p_{11} and p_{12} between the visible and 10.6 μm while a small dispersion was found for q_{44} and p_{44}.

NBSIR 76-1011. **Exploratory study of glowing electrical connections,** W. J. Meese and R. W. Beausoliel, 30 pages (Oct. 1976). Order from NTIS as PB259641.

Key words: arcing/sparking; branch circuit; contact resistance; electrical connections; fire hazard; glowing electrical connections.

This report describes and characterizes with quantifiable electrical and thermal measures the extent to which loose electrical connections in residential-type branch circuits have overheated in the laboratory. With loose electrical connections, which conceivably could be inadvertently duplicated in field installations, but with otherwise normal installation and operating conditions, visible glows have been observed under laboratory test conditions in nominal 120-volt, 15 and 20 ampere branch circuits with both copper and aluminum wire. Characteristics of the glow condition are differentiated from arcing/sparking as sometimes observed in making or breaking electric circuits.

Glowing electrical connections may dissipate as much as 35 watts of power with a current of 15 amps in the circuit and as much as 5 watts with a current of 0.8 amp in the circuit. Temperatures over 750 °F were measured on the "break-off tab" of receptacles. Metal outlet boxes housing glowing connections in an insulated wall test set-up representative of a common type of residential construction attained temperatures in excess of 450 °F. In laboratory tests under repetitive, intermittent and periodic cycles, a connection on a steel wire-binding screw of a receptacle open to the air had sustained glow conditions maintained for over 100 hours. Glowing connections will not perceptibly affect the electrical performance function of lights, appliances or other electrical loads, and will not "blow" fuses, trip circuit breakers or operate ground fault circuit interrupters.

NBSIR 76-1012. **Fire performance testing of bulkhead insulation systems for high strength to weight ship structures,** B. T. Lee, 64 pages (Aug. 1976). Order from NTIS as PB257197.

Key words: aluminum bulkhead; combustion gases; fire endurance; insulation; intumescent paint; potential heat; reinforced plastic; small furnace test; smoke.

Sixteen insulated aluminum bulkhead specimens were subjected to a material screening process as well as evaluated for their comparative fire performance with a 2-foot horizontal slab furnace. Two insulated and two unprotected glass-reinforced plastic specimens were also tested to obtain fire performance data on these structural materials. In addition, painted aluminum and steel panel specimens were included to determine the fire protective merits of two types of intumescent paints. Potential heat release, smoke, and combustion gas generation were also determined for the insulation and coating materials. Specimens insulated with organic base foams released high levels of combustion gases and could contribute considerable heat to an ongoing fire. Specimens insulated with either refractory fibrous material or with mineral wool gave the best overall performance. The same thickness of insulation needed to protect an aluminum panel for over an hour can provide up to 20 minutes of protection for a glass-reinforced plastic panel of the same thickness. The intumescent paints did little to protect the specimens during the fire exposure. Parameters of insulation thickness, heat capacity, density, and thermal conductivity as well as fire duration on specimen temperature were analytically investigated.

NBSIR 76-1013. **Flame spread of carpet systems involved in room fires,** K. M. Tu and S. Davis, 42 pages (June 1976). Order from NTIS as PB256130.

Key words: carpet systems; carpets; fire safety; flame spread; floor coverings; flooring radiant panel test; ignition sources; pill test; room fires.

This study was designed to test the hypothesis that given a situation where a chair or other item of furniture becomes the first item to burn in a room (providing the ceiling and walls are noncombustible), there is little reason to expect involvement of the carpet in the fire beyond the immediate vicinity of the burning object. Four small-sized carpet fire tests and eight full-scale burn room fire experiments were conducted. Experimental data for temperature distribution and incident heat flux to the floor covering were measured in the rooms. General analysis of the experimental results obtained shows this to be the case. It also is evident that the critical radiant flux of the floor covering system is predictive of the extent of burning. From this study, carpet systems used in rooms will not normally spread fire provided they meet the requirements of DOC FF 1-70 (the pill test).

NBSIR 76-1014. **Space heater involvements in fabric fires,** W. D. Hayes, Jr., 25 pages (Mar. 1976). Order from NTIS as PB251414.

Key words: burns; fabric fires; FFACTS; garments; ignition sources; space heaters.

Space heaters are number six in the ranking of most frequently involved direct fabric ignition sources in the Flammable Fabrics Accident Case and Testing System (FFACTS). Eighty-two of the 1573 direct fabric ignition incidents in FFACTS were caused by space heaters. Gas heaters were responsible for 83 percent of all direct garment ignitions where heater type was known. Nightgowns, dresses and robes account for 82 percent of all the garment items directly ignited. Forty-seven percent of the direct garment ignition incidents would probably not have occurred if the presently existing fabric flammability standards had been in effect at the time.

NBSIR 76-1015. **Management of data elements in information processing.** Proceedings of a Second Symposium Sponsored by the American National Standards Institute and by the National Bureau of Standards, October 23-24, 1975, NBS, Gaithersburg, Md., H. E. McEwen, Ed., 263 pages (Apr. 1976). Order from NTIS as PB249530.

Key words: American National Standards; American National Standards Institute; data; data base systems; data elements; data management; data processing; Federal Information Processing Standards; information interchange; information processing; information systems.

Continuing technological advances in computers and communications make possible the integration of data systems and the exchange of data among them on an expanding scale. However, the full effect of these advances cannot be realized unless the need for uniform understanding of the common information (data elements) and their expression in data systems is recognized and a means provided to effectively manage this information. The increasing interrelationships among the data systems of Federal, State and local governments, and with industry and the public add emphasis and dimension to the need for the improved management of data elements in information processing.

These Proceedings are for the second Symposium on the Management of Data Elements in Information Processing held at the National Bureau of Standards on October 23-24, 1975. Over 300 representatives of Federal and State governments, industry and universities from 29 states, from Japan, and the United Kingdom were in attendance. Twenty-nine speakers discussed the role of the data manager, communications needs for data standards, data element directories, standard codes for character and control, use of check characters, data elements in bibliographic data bases, product coding, coding for clinical medicine, human factors, data resource management, data base management systems, and other subjects related to data standardization and data management efforts. *These proceedings include the following papers (indented):*

On-line tactical data inputting: Research in operator training and performance, I. Alderman, *NBSIR 76-1015,* pp. 1-8 (Apr. 1976).

"Turning the Corner" on MIS, a proposed program of data standards in post-secondary education, D. R. Arnold, *NBSIR 76-1015,* pp. 9-16 (Apr. 1976).

ASCII—The data alphabet that will endure, R. W. Bemer, *NBSIR 76-1015,* pp. 17-22 (Apr. 1976).

Techniques in developing standard procedures for data editing, G. W. Covill, *NBSIR 76-1015,* pp. 23-43 (Apr. 1976).

An adaptive file management system, D. L. Dance and U. W. Pooch, *NBSIR 76-1015,* pp. 45-55 (Apr. 1976).

A focus on the role of the data manager, R. M. Davis, *NBSIR 76-1015,* pp. 57-60 (Apr. 1976).

A proposed standard routine for generating proposed standard check characters, P. A. Desjardins, *NBSIR 76-1015,* pp. 61-67 (Apr. 1976).

Methodology for development of standard data elements within multiple public agencies, L. D. England, S. L. Eberle, B. H. Schiff, and A. S. Huffman, *NBSIR 76-1015,* pp. 69-76 (Apr. 1976).

The role of the internal auditor in data management, R. H. Fahnline, *NBSIR 76-1015,* pp. 77-81 (Apr. 1976).

Semantic coding and data element characterization in medical computing, E. R. Gabrieli, *NBSIR 76-1015,* pp. 83-89 (Apr. 1976).

Principles and concepts of data resource managment system development, A. Hochman, *NBSIR 76-1015,* pp. 91-98 (Apr. 1976).

The design of data elements: A data base perspective, M. A. Huffenberger, *NBSIR 76-1015,* pp. 99-112 (Apr. 1976).

A challenging aspect of word processing, V. G. Kehler, *NBSIR 76-1015,* pp. 113-118 (Apr. 1976).

Data element lexicon needs a new home, R. J. Kirkbride, *NBSIR 76-1015,* p. 119 (Apr. 1976).

Check characters and the "Self-Checking String"—What, where, why, when and how, J. R. Kraska, J. R. Nelson, and E. Hellerman, *NBSIR 76-1015,* pp. 121-138 (Apr. 1976).

The standards implications of the developing interrelationships between on-line bibliographic retrieval, data manipulation and micrographics display, R. M. Landau, *NBSIR 76-1015,* pp. 139-145 (Apr. 1976).

Product coding-one number from maker to user, J. T. Langan, *NBSIR 76-1015,* pp. 147-150 (Apr. 1976).

Development of a data dictionary/directory using a data base management system, E. K. C. Lee and E. Y. S. Lee, *NBSIR 76-1015,* pp. 151-162 (Apr. 1976).

Systems design considerations for the U.S. Army Materiel Command (AMC) data element dictionary/directory system, F. Puente, *NBSIR 76-1015,* pp. 163-167 (Apr. 1976).

A data element directory for a state motor vehicles agency, J. Roberts, *NBSIR 76-1015,* pp. 169-190 (Apr. 1976).

An integrated dictionary for systems and data components, C. Shields, *NBSIR 76-1015,* pp. 191-193 (Apr. 1976).

An information documentation language: A framework for deriving information from data, W. M. Taggart, Jr., *NBSIR 76-1015,* pp. 195-210 (Apr. 1976).

International standards for data transmission, V. N. Vaughan, Jr., *NBSIR 76-1015,* pp. 211-220 (Apr. 1976).

An information management view of data management, M. G. Wallis, *NBSIR 76-1015,* pp. 221-230 (Apr. 1976).

Data standardization, H. S. White, Jr., *NBSIR 76-1015,* pp. 231-235 (Apr. 1976).

Data element analysis and use of a relational data, M. E. Williams, S. Preece, and S. Rouse, *NBSIR 76-1015,* pp. 237-252 (Apr. 1976).

Status of the Army Materiel Command's progression from reports control to data element management, E. F. Young, *NBSIR 76-1015,* pp. 253-256 (Apr. 1976).

NBSIR 76-1016. **Mobile home smoke detector siting study,** W. M. Gawin and R. G. Bright, 55 pages (May 1976). Order from NTIS as PB254177.

Key words: detector sensitivity; fire detectors; mobile homes; photoelectric smoke detectors; smoke detector installation; smoke detector placement; smoke detectors.

An investigation was conducted to evaluate the significance of smoke detector locations to response time for a specific set of fire conditions in a mobile home. Parameters having the potential of affecting response time include: the physical location within a mobile home such as inside wall vs. outside wall or wall vs. ceiling installations; the impact of air circulation resulting from the operation of the heating, ventilating, and air-conditioning system; and the basic detector parameter of smoke detector alarm threshold. For the study only photoelectric-type smoke detectors were used. These detectors utilize the Tyndall Effect in their sensing mechanism. This limitation was imposed to limit the number of variables. Detector response was evaluated for fires in both smoldering and flaming modes. The results of the study provide a case for wall installations as opposed to ceiling installations. Further, inside wall installations may be marginally superior to outside wall installations. The most significant finding of the study suggests that, when in operation, the forced-air circulating system has a major delaying effect on detector response time to a given fire size.

NBSIR 76-1017. **Interaction of blood proteins with solid surfaces,** R. R. Stromberg, B. W. Morrissey, L. E. Smith, W. H. Grant, and R. E. Dehl, 38 pages (Mar. 5, 1976). Order from NTIS as PB251917.

Key words: adsorption; blood protein; bound fraction; ellipsometry; implants; polymer adsorption; protein adsorption; synthetic implants.

The overall objective of this investigation is to help characterize materials used for implants in the cardiovascular system and to develop test methods to aid in the selection of the most useful materials. The focus of the work has been an investigation of the adsorption of blood proteins on surfaces with special emphasis on changes in conformation occurring upon adsorption. An important component has been an ellipsometric examination of materials produced by contractors of the NHLI Biomaterials Program that were considered to be of potential clinical value. In contrast to the behavior of serum albumin and prothrombin, conformational changes in γ-globulin and β-lactoglobulin occurring as a consequence of changing surface population were previously reported and were confirmed during this reporting period. An investigation of conformational changes at very short adsorption time was initiated. Adsorption, desorption and exchange of adsorbed protein in solution was studied. The results indicate strong hydrophobic bonding between the protein and the synthetic polymer surface.

NBSIR 76-1018. **Evaluation of the fire performance of carpet underlayments,** S. Alderson and L. Breden, 69 pages (Sept. 1976). Order from NTIS as PB257779.

Key words: carpets; fire; flammability; floor coverings; pad; underlayments.

A series of carpet underlayments was evaluated for fire performance in a corridor configuration using the same carpet in all tests. Carpets with underlayments flashed over during corridor tests. In a series of small-scale tests, such as the smoke density chamber and the radiant panel, the flammability properties of the carpet tended to mask the flammability properties of the underlayment. The exception to this masking effect was the results from the flooring radiant panel test where the thermal conductivity of the underlayment influenced the burning characteristics of the carpet. High concentrations of toxic combustion products were observed at the time of flashover in the corridor, with both cellulosic and synthetic underlayments. Smoke optical density values for the various carpet plus underlayment combinations were approximately the same in the flaming mode, except for the integral pad system which has a higher value.

NBSIR 76-1019. **Notes on the preparation of silicon density artifacts,** R. M. Schoonover, 11 pages (Feb. 1976). Order from NTIS as PB251944.

Key words: density; etching; grinding; sawing; silicon; standard; weighing.

The preparation of single crystal silicon density standards as normally done at the National Bureau of Standards is described.

This description is designed to guide other laboratories in construction of these standard artifacts and to facilitate their intercomparison.

NBSIR 76-1020. **Guide criteria for laboratory evaluation of backflow prevention devices for protection of potable water supplies,** G. C. Sherlin, R. W. Beausoliel, and L. S. Galowin, 44 pages (Mar. 1976). Order from NTIS as PB258256.

Key words: backflow; backflow prevention devices; back pressure; backsiphonage; guide criteria; potable water protection; plumbing guide criteria.

This report describes laboratory evaluation procedures which could be required for the approval of backflow prevention devices used to protect potable water supplies against contamination. Performance-based requirements, criteria, and general evaluation considerations that administrative authorities should require for approval of devices are presented. Recommendations for the development of tracer tests are submitted for further consideration. This document results from an investigation undertaken for the Environmental Protection Agency (EPA).

NBSIR 76-1021. **Fire spread along a mobile home corridor,** E. K. Budnick, 58 pages (July 1976). Order from NTIS as PB257101.

Key words: corridor fire test; interior finish material; intumescent coating; life safety; mobile home; smoke detector; surface flame spread.

A series of tests was conducted in the corridor area of a typically constructed mobile home. These tests were designed to: (1) evaluate the performance of a variety of combinations of wall and ceiling materials as a result of exposure to a typical ignition in a full-scale mobile home corridor, and (2) determine the relationship between full-scale tests and laboratory flammability tests, particularly the ASTM E-84 tunnel test, a measure of surface flame spread.

The tests were restricted to one set of conditions in which the living room at the end of the corridor was exposed to a fire resulting from ignition of a standardized 6.4-kg (14-lb) wood crib. Nine tests were conducted with seven different combinations of wall and ceiling materials.

Performance of the various combinations of wall and ceiling materials was examined based on the time to reach untenable conditions in the corridor. Measurements utilized in evaluating levels of tenability included gas temperatures, surface temperatures, irradiance, concentrations of oxygen and carbon monoxide, and smoke densities.

Under this set of test conditions, it was found that the extent of fire spread and the time to reach untenable conditions are significantly influenced by the surface flame spread characteristics of the wall and ceiling finish materials in the corridor.

For a mobile home corridor with conventional wall and ceiling linings (ASTM E-84:FSC = 200 max), untenable conditions were reached in the corridor in less than four minutes. With class A (FSC = 25 max) wall and ceiling materials in the corridor, untenable conditions were not reached.

NBSIR 76-1022. **Evaluation of thrown objects tests for proposed safety standard for power lawn mowers,** D. C. Robinson and R. B. Clough, 25 pages (June 1976). Order from NTIS as PB259628.

Key words: dispersion tests; lawn mowers; penetration tests; power lawn mowers; safety standard; thrown objects tests.

An evaluation was made of thrown objects dispersion and penetration tests which have been developed for a proposed safety standard for power lawn mowers. To evaluate the proposed laboratory dispersion tests, supplementary outdoor dispersion tests were conducted on walk-behind lawn mowers in which actual grass cutting conditions were simulated. A description of these outdoor tests, a comparison of the outdoor and laboratory dispersion tests for a sample of walk-behind lawn mowers, and an evaluation of the proposed dispersion and penetration tests is given. The evaluation includes a theoretical discussion of the penetration of thrown objects which is related to experimental results in terms of the shape, size and velocity of the thrown projectiles.

NBSIR 76-1023. **Direct comparisons of the NBS absorbed dose calorimeters irradiated with 20 and 50 MeV electrons,** S. R. Domen, P. J. Lamperti, and T. Mikado, 23 pages (July 1976). Order from NTIS as PB256191.

Key words: absorbed dose; calorimeter; calorimetric comparisons; electron beams.

Two NBS absorbed dose calorimeters were compared in 20 and 50 MeV electron beams that were scattered with lead foils of various thickness. The internal structures of the calorimeters are identical. The nonportable model is enclosed in a 40 cm × 40 cm × 30 cm thick graphite medium while a 30 cm diameter × 15 cm thick graphite medium was used to enclose the portable model. Measured results indicate that the three internal bodies of the calorimeters and their measuring circuits were constructed with sufficient care to produce essentially identical calorimetric responses to about 0.1 percent.

NBSIR 76-1024. **Statistical analysis of blood lead levels of children surveyed in Pittsburgh, Pennsylvania: Analytical methodology and summary results,** W. D. Urban, 75 pages (Apr. 1976). Order from NTIS as PB255876.

Key words: blood; blood lead; children; housing; lead paint; lead poisoning; surveys.

A survey was conducted in Pittsburgh, Pennsylvania to estimate the incidence of lead paint in housing and to develop a survey methodology that could be used in other metropolitan communities for that purpose. A secondary objective of the survey was to determine whether a causal relationship could be found between blood lead levels of children aged 7 years or less, living in the surveyed dwellings and the presence of lead paint in those dwellings. This report deals with the latter objective. For the children tested in Pittsburgh, the incidence of elevated blood lead levels defined as 40 micrograms of lead per 100 milliliters of blood or greater, was found to be less than 1 percent, too low to permit the establishment of a causal relationship. There was a significant correlation between the blood lead levels of the children living in the older homes and the fraction of contaminated surfaces within the dwellings. In addition, there was a significant correlation between the blood lead levels and the age of the dwellings in which the children resided. This correlation appeared to be independent of the lead paint levels in the dwellings. This report presents a summary of the survey procedures, the blood lead measurement process and associated problems and the more significant results of the analysis of the housing/blood lead data obtained in Pittsburgh.

NBSIR 76-1025. **Air-mobility rigid shelter systems,** T. W. Reichard and L. F. Skoda, 99 pages (Nov. 1975). Order from NTIS as PB251753.

Key words: durability; field inspection; foam and beam; honeycomb; impact; lightweight structures; military; reliability; sandwich panel; shelter.

This interim report covers the first portion of a long-range investigation dealing with the design and durability of lightweight, rigid structures (shelters) used by the military as combination shipping containers and housing for tactical and life-support services. This report covers the results of field and laboratory studies intended to correlate functional and structural problems with in-service conditions. It was found that water leakage into the shelters and into the sandwich panels was probably the basic problem area although many shelters appeared to have been defective at the time of delivery. It was found that, under adverse conditions, a polyamid paper honeycomb core would be significantly better for the sandwich panels than is the draft paper core now used. Major delaminations of the sandwich panels could not be correlated with impact damage such as would be caused by forklift bumps.

Subsequent reports will present the results from a structural analysis of and field test on shelters subjected to typical dynamic and static loading conditions.

NBSIR 76-1027. **A survey of manufacturers' views on the ETIP procurement experiment. Volume three: Ranges,** P. C. Goodman, 33 pages (Feb. 1976). Order from NTIS as PB253243.

Key words: energy-efficient products; Experimental Technology Incentives Program; gas and electric ranges; life-cycle costing; procurement experiments.

This report describes the findings of a survey of nine gas and electric range manufacturers by the Center for Consumer Product Technology. The survey was conducted for the Experimental Technology Incentives Program (ETIP) as part of its evaluation of a Federal Supply Service (FSS) procurement of ranges. Survey questions were designed to obtain manufacturers' views on the use of Government procurement policies to increase the rate of introduction of new technologies into the consumer marketplace. The questions covered the following areas: (1) reasons for participation or nonparticipation of a manufacturer in the ETIP experiment; (2) problems a manufacturer encounters with existing Federal procurement practices; (3) acceptability of using life-cycle costing in the bidding procedure; and (4) effect of the most recent Government procurement on present and future company operations. Results of the survey are reported, and implications are drawn for future ETIP studies of Government procurement activities.

NBSIR 76-1028. **A new concept for automatic detection and extinction of fires,** D. Lay, 20 pages (Mar. 1976). Order from NTIS as PB251415.

Key words: automatic sprinklers; carbon dioxide; fire detection; fire extinguishment; flame detection; heat detection; smoke detection.

The use of automatic fire detectors to trigger fire extinguishment systems has gone on for many years. Systems of this type use a variety of extinguishing agents including water, carbon dioxide and, most recently, the halogenated agents.

Automatic extinguishing systems with practically an unlimited supply of agent suffer from the fact that these systems often continue in operation long after the fire is out resulting in additional damage. This doesn't occur with those systems having limited supplies such as carbon dioxide systems and the like. However, these systems are only successful if: (1) their original design was correct; (2) no unanticipated changes are made in the area or materials to be protected; and (3) extinguishment commences at a time when successful extinguishment is possible.

This paper describes how the disadvantages recommended above can be avoided, to a large extent, with a modified design for permanently-installed, automatic extinguishing systems and how systems can be provided which will only discharge extinguishant at the proper time and in the proper amount.

NBSIR 76-1029. **Unitary heat pump specification for military family housing,** C. W. Phillips, B. A. Peavy, and W. J. Mulroy, 30 pages (Aug. 1976). Order from NTIS as PB261199.

Key words: heating and cooling; military family housing; specification; unitary heat pump.

The purpose of this report is to establish, for unitary heat pump equipment, the requirements for performance, testing, rating, design, safety, serviceability and reliability for system and components; and conformance conditions. This report is intended for guidance in military procurement and applies to hermetic electrically-driven vapor-compression unitary heat pumps of the remote (split) and packages (integral) types, the air-to-air and water-to-air classes, and sizes from 17,000 to 84,000 Btu/hr for both heating and cooling functions.

NBSIR 76-1031. **Shape dependence of light-scattering behavior of dust particles,** R. Zerull, 23 pages (June 1976). Order from NTIS as PB253932.

Key words: aerosols; dusts; light-scattering; Mie theory; particles; Rayleigh scattering.

The most important characteristic which determines the light-scattering behavior of particles is their size distribution, their concentration, their shape, and their material composition. This paper concerns itself with the measurement of the effects of shape on light-scattering behavior. Only a few shapes have been appropriately modeled and if the shape dependence can be determined, the remaining characteristics pose no special difficulties.

NBSIR 76-1034. **Chemical thermodynamic properties of compounds of sodium, potassium and rubidium: An interim tabulation of selected values,** D. D. Wagman, W. H. Evans, V. B. Parker, and R. H. Schumm, 76 pages (Apr. 1976). Order from NTIS as PB254460.

Key words: enthalpy; entropy; Gibbs energy; heat capacity; potassium compounds; rubidium compounds; sodium compounds; standard reference data; thermochemical tables.

Selected values are given for the thermochemical properties of the more common compounds of sodium and potassium. A more extensive set of selections is provided for rubidium compounds. The properties included, where data are available, are enthalpy of formation at 0 K and 298.15 K, $\Delta Hf(0)$ and $\Delta Hf(298)$, Gibbs energy of formation, entropy and heat capacity at 298.15 K, $\Delta Gf(298)$, S(298) and Cp(298) and the enthalpy difference between O K and 298.15 K, H(298)-H(O). The values are consistent with the tables issued earlier in the NBS Technical Note 270 series.

NBSIR 76-1037. **Integral measurement procedures for determining particle size in aerosols,** F. J. Kraus, 38 pages (May 1976). Order from NTIS as PB253933.

Key words: aerosols; ionization chambers; light attenuation; scattered light; smoke detectors; test methods.

In assessing the performance of smoke detectors in the laboratory, it is necessary to have standardized smoke measurement devices which function according to the same principles as the smoke detectors under test. In developing these measurement devices, a need exists to determine, as precisely as possible, the effects of the smoke characteristics on the measurement devices. This paper presents the correlation between smoke characteristics and comparative measuring devices important in smoke detector test work and how these measuring devices can also be used as aerosol measuring devices.

NBSIR 76-1038. **NBS InterAgency transducer project, Progress Report No. 3,** P. S. Lederer and J. S. Hilten, 24 pages (Apr. 1976). Order from NTIS as PB251918.

Key words: calibration; dynamic; electronic flash; photoflash bulb; pressure; pressure measurement; pressure transducer; pressure transducer response; response; thermal transient; transducer; zero shift.

Concluding efforts related to the development of a test method for evaluating the effects of short-duration, thermal radiant-energy transients on pressure-transducer response are described. The method consists of monitoring pressure-transducer output (zero shift with the transducer at atmospheric pressure) as the transducer is exposed to radiation resulting from the ignition of a photographic flashbulb or from the discharge of an electronic flash. Thermal energy pulses as great as 0.1 J/cm^2, with durations of about 6 ms, have been generated using an electronic flash; pulses of up to 2.2 J/cm^2, with durations of about 37 ms, have been generated using No. 22 flashbulbs. Flood-flash FF-33 lamps were also investigated; their use is not recommended. In tests with No. 22 bulbs, 25 commercial pressure transducers have shown zero shifts ranging from 0.4 to about 400 percent of the full-scale output.

Transducer-related tasks being performed for other agencies are also described briefly, and other recent NBS publications of interest to the transducer community are identified.

NBSIR 76-1039. **Evaluation of selected connectors for aluminum wire in residential structures,** O. B. Laug, 37 pages (Mar. 1976). Order from NTIS as PB254047.

Key words: aluminum wire; splices; terminals.

Systems of connecting aluminum wire for possible use in receptacle outlets and elsewhere in 15 and 20 ampere branch circuits in residences are available as practical alternatives to the presently used mechanisms such as the wire binding screw and the twist-on "wire nut" connector. The alternative systems are based on the principle of high deformation of the wire in the connection to achieve more permanent metal-to-metal fittings and/or wire splice devices of several designs. They involve either crimping the device around the wire or swagging the wire into the device with special tools. Based on tests, basic connection performance of several high-deformation connectors has been established. The results indicate that certain designs of connectors operate with stability and without dangerously over-heating under accelerated laboratory tests. The tools, however, to be used to crimp terminals are not only bulky and awkward to use but quite expensive. Moreover, they must be correctly coordinated with the terminals and sizes of wires used. There is danger that a misadjusted or improper tool and/or terminal may be used with particular wire or wires which could result in a poor connection. Some improvements in the design of the assembly tools and in the devices themselves would reduce certain installation difficulties encountered during testing, and certain connectors could be slightly modified to avoid human errors during assembly. Use of these systems and conformance with established codes and standards do not appear to present major problems.

NBSIR 76-1040. **Points of view in testing flame detectors,** M. Schnell, 24 pages (May 1976). Order from NTIS as PB254178.

Key words: detection; fire detectors; flame detectors; heat detectors; infrared detectors; smoke detectors; testing; ultraviolet detectors.

The general principles for type testing the fire detectors which are already in use in the assessment of heat and smoke detectors are summarized. These include the so-called basic tests and the trial tests. The trial tests were intended to include all test fires in order to ensure comparability of tested fire detectors. Additional test fires are proposed which are intended to permit differentiated comparison of flame detectors between one another. The main problem in assessing the performance of flame detectors during environmental influences is the selection of a suitable radiation source for reproducibly simulating the characteristic "flame." The requirements that this radiation source must fulfill are dealt with and various realizations involved are discussed. The practical testing of infrared flame detectors to the basic tests is described. In addition, a suggested test apparatus for ultraviolet flame detectors is dealt with.

NBSIR 76-1041. **Security analysis and enhancements of computer operating systems,** The RISOS Project, Lawrence Livermore Laboratory, 70 pages (Apr. 1976). Order from NTIS as PB257087.

Key words: BBN-TENEX; IBM OS/360; operating system security; security flaws; software security; taxonomy of integrity flaws; UNIVAC 1100 Series OS.

The protection of computer resources, data of value, and individual privacy has motivated a concern for security of EDP installations, especially of the operating systems. In this report, three commercial operating systems are analyzed and security enhancements suggested. Because of the similarity of operating systems and their security problems, specific security flaws are formally classified according to a taxonomy developed here. This classification leads to a clearer understanding of security flaws and aids in analyzing new systems. The discussions of security flaws and the security enhancements offer a starting reference for planning a security investigation of an EDP installation's operating system.

NBSIR 76-1043. **An economic analysis of residential abandonment and rehabilitation,** P. F. Colwell, 111 pages (May 1976). Order from NTIS as PB254347.

Key words: housing; housing demand, supply, needs; housing rehabilitation; land economics; market adjustments; optimization and feasibility; rehabilitation, conservation.

This paper is an analysis of market and governmental factors which lead to socially inefficient rehabilitation and abandonment decisions. Its purpose is to abstract from complex problems related to the rehabilitation and abandonment of residential buildings by identifying the essential characteristics of the problems and the role some past and existing social programs have had on aggravating or mitigating these problems. Alternative programs are analyzed for their potential effects on these problems, however policy recommendations are not made.

NBSIR 76-1046. **Improved building design through the psychology of perception: Perceptual selectivity applied to livability and safety with sample performance requirements,** N. Starnes, R. Wehrli, and R. Cormack, 103 pages (July 1976). Order from NTIS as PB256476.

Key words: architectural psychology; architectural research; building research; building safety; perception; stair safety research.

For over a decade, architects have been calling for applications from social science which would contribute to building design better suited to the building's users. This report provides such applications relying upon the state-of-the-art knowledge of the psychology of perception, showing how human perception operates in the everyday use of buildings, and then drawing upon this rationale to present building requirements to guide the

design and construction of safer stairs in future buildings. The building safety "requirements" have been written in the format and style of the *Guide Criteria for the Design and Evaluation of Innovative Housing Systems,* a housing performance specification written by NBS for HUD's large housing experiment, Operation Breakthrough. The report is directed toward both building designers (who could consider the use of the stair safety requirements for their own building projects) and architectural psychology researchers (who could take the proposed requirements as a set of hypotheses in further research and experimentation).

NBSIR 76-1049. **The electron factor in catalysis on metals electrocatalysis on nonmetallic surfaces,** L. H. Bennett and A. D. Franklin, 71 pages (May 1976). Order from NTIS as PB256600.

Key words: catalysis; electrocatalysis; electrochemistry; electrodes; fuel cells; surface physics and chemistry.

Two related workshops were held at the National Bureau of Standards in Gaithersburg, MD, December 9-12, 1975, in topics of importance for energy conversion. These topics, concerned with some of the science underlying the development of fuel cells for electric utility use, are: (1) The Electron Factor in Catalysis on Metals; and (2) Electrocatalysis on Non-Metallic Surfaces.

This report includes discussions of the needs and expected benefits, lists of attendees, descriptions of the programs, and summaries of the major problems, advances, and opportunities revealed by the workshops.

NBSIR 76-1050. **Tornado-borne missile speeds,** E. Simiu and M. Cordes, 63 pages (Apr. 1976). Order from NTIS as PB253111.

Key words: missiles; nuclear engineering; structural engineering; tornadoes; wind.

At the request of the U.S. Nuclear Regulatory Commission (NRC) the National Bureau of Standards (NBS) has carried out an independent investigation into the question of tornado-borne missile speeds, with a view to assisting NRC in identifying pertinent areas of uncertainty and in estimating credible tornado-borne missile speeds—within the limitations inherent in the present state of the art. The investigation consists of two parts: 1) a study, covered in this report, in which a rational model for the missile motion is proposed, and numerical experiments are carried out corresponding to various assumptions on the initial conditions of the missile motion, the structure of the tornado flow, and the aerodynamic properties of the missile; 2) a theoretical and experimental study of tornado-borne missile aerodynamics, conducted by Colorado State Univ. (CSU) under contract with NBS, to be covered in a separate report by CSU. In the present report, the factors affecting missile motion, and their influence upon such motion, are examined. Information is provided on a computer program developed for calculating missile speeds. Maximum speeds for a number of specified potential tornado-borne missiles are presented, corresponding to a set of assumptions believed by the writers to be reasonable for design purposes. It is pointed out that higher speeds are conceivable if it is assumed that certain circumstances, examined in the body of the report, will obtain. It is the judgment of the writers that the probabilities of occurrence of such higher speeds for any given tornado strike are low. More than qualitative estimates of such probabilities, are however, beyond the scope of this investigation.

NBSIR 76-1052. **Naval shipboard fire risk criteria—Berthing compartment fire study and fire performance guidelines,** B. T. Lee and W. J. Parker, 86 pages (Sept. 1976). Order from NTIS as PB258118.

Key words: fire tests; flame spread; heat release rate; ignition; reduced scale models; room fires.

Judicious application of shipboard materials and choice of compartment furnishings can significantly reduce the threat of serious fire on board ship. Unfortunately the fire performance of materials is currently difficult to ascertain from laboratory fire tests on the materials. Full size and quarter-scale compartment fires in conjunction with an analytical treatment were performed to obtain an improved understanding of the relationships between the laboratory fire test assessment and the observed behavior of materials in actual fires. The compartment fire experiments indicated that the temperature of the hot air layer below the ceiling is a suitable quantitative measure of the level of fire buildup in a compartment. When this temperature exceeds 700 °C there is sufficient radiation from the hot air layer and the heated upper surfaces to cause ignition of all combustible materials in the compartment. For a $3 \times 3 \times 2.1$ m ($10 \times 10 \times 7$ ft) space lined with asbestos millboard having a 0.68×1.9 m (27×75 in) open doorway a heat production rate of about 72 kW/m^2 (6.3 Btu/s/ft^2) of deck area is enough to attain this condition. Fires in some bunk configurations alone could exceed this critical rate of heat generation. Ventilation and its points of application were found to be very important considerations. Observations of the fire scenarios in the compartment tests along with an empirical and analytical analysis of fire growth in compartment spaces have resulted in an improved application of the fire test ratings. Consequently more rational design rules for fire safe material usage have been developed taking into account the ignitability, flame spread, rate of heat release, potential heat and smoke generation potential of materials. The study also indicated the practicality of using quarter-scale fire tests for studying fire performance in full size compartments.

NBSIR 76-1054. **An appraisal of tests and standards for the evaluation of electrical insulating fluids,** D. B. Miller, V. E. Bower, F. R. Kotter, O. Petersons, M. M. Birky, C. M. Huggett, and A. Macek, 124 pages (May 14, 1976). Order from NTIS as PB253110.

Key words: askarel; capacitors; insulating fluids; liquid insulators; polychlorinated biphenyls; transformers.

Based on a literature study and interviews with representatives of the electric utility industry, manufacturers of insulating fluids and electrical apparatus, government regulatory agencies, organizations preparing standards and codes, trade associations and independent testing laboratories, the status of existing standards and test procedures for insulating fluids is reviewed. Askarel-type transformers and capacitors are described and the characteristics of several currently-used as well as new candidate insulating fluids are given. The possible impact of codes and government regulations on the introduction of new fluids into use is reviewed. Needs for new or revised test procedures and standards are noted and recommendations made for research and development efforts as well as administrative actions to facilitate the qualifying of new insulating fluids as acceptable replacements for the askarels currently in use in a certain class of transformers and capacitors.

NBSIR 76-1056. **Analysis of solar energy system for the GSA demonstration office building at Manchester, New Hampshire,** T. Kusuda, S. T. Liu, J. W. Bean, and J. P. Barnett, 35 pages (Mar. 1, 1976). Order from NTIS as PB254179.

Key words: energy conservation; GSA/Manchester building; solar collector; solar heating and cooling; thermal storage.

The energy conservation demonstration building of the General Services Administration to be built in Manchester, New Hampshire, has been planned to be partially heated and cooled by solar energy. Presented in this report are results of a study made at the National Bureau of Standards to determine the effect of solar collector sizes and the amount of storage on the overall energy consumption of the building. It was found that the fuel savings attainable by the use of solar energy for heating and cooling of the building will be less significant as the size of the collector and the amount of storage are increased beyond certain limits.

NBSIR 76-1058. **Performance of mobile homes—Summary report,** J. H. Pielert, W. E. Greene, Jr., L. F. Skoda, and W. G. Street, 143 pages (Apr. 1976). Order from NTIS as PB262097.

Key words: computer techniques; construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards.

This project was funded at the National Bureau of Standards by the Department of Housing and Urban Development with the objective of documenting mobile home performance problems and relating them to possible inadequacies in the ANSI A119.1 Standard for Mobile Homes and the mobile home enforcement process. Additionally, the durability of mobile home components was a study objective for potential use in mortgage insurance evaluation. Mobile home performance data were obtained for 4,105 mobile homes, categorized and related to the project objectives. This summary report is the last of a series of four project reports. It documents the project approach, results of the various tasks, and presents conclusions and recommendations. This was a problem-oriented study and did not attempt to document the many areas of satisfactory mobile home performance.

NBSIR 76-1059. **Intermediate minimum property standards for solar heating and domestic hot water systems,** Solar Energy Program Team, Center for Building Technology, 171 pages (Apr. 1976). Order from NTIS as PB257086.

Key words: solar buildings; solar collectors; solar domestic hot water systems; solar heating; standards; thermal storage.

This report presents standards for the use of solar heating and domestic hot water systems in residential applications. The standards have been developed for application in numerous housing programs of the Department of Housing and Urban Development and are a companion document to be used in conjunction with the HUD "Minimum Property Standards for One and Two Family Dwellings," 4900 and "Minimum Property Standards for Multifamily Housing," 4910. To the greatest extent possible, these standards are based on current state-of-the-art practice and on nationally recognized standards including the MPS and the HUD "Interim Performance Criteria for Solar Heating and Combined Heating/Cooling Systems and Dwellings."

NBSIR 76-1060. **NBS interagency transducer project. Progress Report No. 4,** P. S. Lederer, J. S. Hilten, C. F. Vezzetti, and J. F. Mayo-Wells, 26 pages (June 10, 1976). Order from NTIS as PB253934.

Key words: coatings; photoflash bulb; pressure transducer; protective coatings; thermal radiant-energy response; thermal transient response; transducer.

Initial experimental efforts are described relating to the development and evaluation of means to reduce the effects produced by thermal radiant-energy transients and other thermal inputs on pressure-transducer response. Results from earlier work suggest that a major source of the thermally induced zero shifts observed in a number of pressure transducer designs is thermal energy propagated through the diaphragm to the sensing element. For many transducer designs, the temperature at the back side of the diaphragm provides a convenient measure of the energy reaching the sensing element. Accordingly, a series of tests was carried out to investigate the effects of a variety of protective coatings on the amount and rate of energy transmission through the diaphragm as revealed by measurements of the diaphragm back-side temperature. For purposes of experimental simplicity, mounted thin metal disks are used to simulate transducer diaphragms, and the temperature histories of both bare and protected disks are measured with thermocouples following exposure of the disks to thermal radiant-energy transients (of approximately 20 mJ/mm^2 at the disk) generated by No. 22 photographic flashbulbs. Protective means investigated include various materials, such as tapes, greases, and room-temperature-vulcanizing rubbers (RTVs), applied directly onto the disks as coatings. Data are given for each protective material tested.

A description of other transducer-related work and publications is given in an appendix.

NBSIR 76-1061. **An annotated bibliography on proton affinities,** K. Hartman, S. Lias, P. J. Ausloos, and H. M. Rosenstock, 52 pages (July 1976). Order from NTIS as PB256328.

Key words: basicity; bibliography, appearance potential; heat of formation; ion-molecule equilibrium; proton affinity; proton transfer.

This bibliography consists of approximately 150 references about proton affinities which covers the period from 1932 through 1975. This includes experimental determinations of proton affinities in the gas phase (through observation of proton transfer reactions, ion-molecule equilibria, and appearance potential measurements) as well as determinations from crystal lattice energies and other miscellaneous techniques. Also included are reviews concerned with or related to proton affinity determinations.

NBSIR 76-1063. **Air leakage measurements in a mobile home,** C. M. Hunt, S. J. Treado, and B. A. Peavy, 27 pages (Aug. 1976). Order from NTIS as PB257102.

Key words: air infiltration measurement; air leakage measurement; mobile home tightness; sulfur hexafluoride tracer measurement.

Air leakage measurements were made in a mobile home using sulfur hexafluoride (SF_6) as a tracer gas. The home was located in an environmental chamber where it was possible to measure and control the temperature outside the home. The effect on infiltration rate of a number of variables was determined. These included inside-outside temperature difference, simulated wind, installation of storm windows, opening of doors, and operation of the furnace fan. Experiments were also performed in which a fan was sealed to an opening in the house and inside-outside pressure difference measured as the fan blew air into or out of the structure at measured rates.

NBSIR 76-1064. **Existing architectural information indexing systems,** R. J. Kapsch, 68 pages (Mar. 1976). Order from NTIS as PB254181.

Key words: architectural indexing systems; architecture; building; construction; design; information; information retrieval system.

Architectural indexing systems are those mechanisms which we use to organize information concerning how and what to

build. Architectural indexing systems are a means of organizing available information in a manner that can readily be grasped by the user. As such, architectural indexing systems are an important component part of architectural information systems. This report reviews and summarizes existing architectural indexing systems presently used in the United States and overseas. Indexing systems reviewed are classified into (1) one way divisions, (2) two way divisions, (3) thesauri and other indexing systems.

NBSIR 76-1066. **Center for consumer product technology publications, November 1974 to April 1976,** S. Halpin, 13 pages (June 1976). Order from NTIS as PB254473.

Key words: bibliographies; consumer product safety; consumer product standards; consumer product technology; law enforcement equipment; law enforcement equipment standards; product performance; product safety.

"Center for Consumer Product Technology Publications, November 1974 to April 1976" lists only publications prepared by the members of the Center for Consumer Product Technology staff, by NBS personnel under contract or grant to the Center or by NBS personnel or external laboratories under contract or grant from the Center are cited. Articles published in NBS house publications also are cited.

NBSIR 76-1067. **Mathematical approaches to evaluating aircraft vertical separation standards,** J. F. Gilsinn and D. R. Shier, 50 pages (May 1976). Order from NTIS as PB257195.

Key words: aircraft; air transportation; air traffic control models; altimetry; altitude; aviation; collision risk; error analysis; mathematical models; safety; separation; vertical separation.

Above Flight Level 290, current regulations require aircraft to be separated vertically by at least 2000 feet. Because of increased traffic desiring to fly at these altitudes, the possibility of reducing the required separation (while maintaining acceptable safety levels) is under study. This report details many of the components of vertical position error and classifies them into three major categories: static pressure system error, altimeter instrument error, and pilot response error. Two models for use in evaluating separation standards, the root sum of squares (RSS) approach and the Reich collision risk model, are described together with their respective advantages and disadvantages. A final section includes recommendations for a carefully designed data collection effort and discusses potentially important considerations for such a design.

NBSIR 76-1069. **Environmental effects on the strength of a glass fiber-reinforced-plastic rod material,** N. Halsey and L. Mordfin, 38 pages (July 1976). Order from NTIS as PB256296.

Key words: antenna-support materials; environmental degradation; guys, nonmetallic; marine atmospheres; plastics, fiber-reinforced; pultrusions; stress-rupture testing; sunlight; ultraviolet radiation; weatherability.

Environmental stress-rupture test methods were developed for studying the weatherability of materials under stressed exposure to marine atmospheres and intense sunshine. These laboratory test methods were applied to a coated, pultruded, glass fiber-reinforced-plastic rod product, with the marine atmosphere simulated by a saltwater fog and intense sunshine simulated by ultraviolet radiation. Static tests of the material, conducted both before and after the environmental exposures, were used to characterize both the as-received mechanical properties of the product and the reductions in tensile strength attributable to the weathering actions. The experimental results essentially confirmed the rod manufacturer's contention that the effects of sunlight and weathering on the product range from none to slight. For applications as antenna guys, the results suggest that the strength limitations imposed on rods by conventional end fittings, and by the fact that rods are frequently bowed rather than straight, tend to overshadow any strength reductions attributable to environments of the types considered here.

A failure analysis of a tower guy, fabricated from material of the type tested in this investigation, is given in an appendix.

NBSIR 76-1070. **Evaluation of backflow prevention devices: A state-of-the-art report,** G. C. Sherlin and R. W. Beausoliel, 142 pages (June 1976). Order from NTIS as PB260913.

Key words: backflow; backflow preventers; back pressure; back-siphonage; cross connections; health hazard; potable water; vacuum breaker; water supply.

A significant potential for potable water supply contamination exists within all water supply systems due to backflow and cross connections. Surveillance of the water supplies to protect from such hazards requires continuing vigilance by the administrators of cross-connection control programs, and continuing upgrading of technical criteria and methods of evaluation.

The Environmental Protection Agency assists local (usually municipal) authorities, through the State water supply agency, in establishing and operating cross-connection control programs. Essential to these programs are (1) information on the suitability of commercially available devices for use in potentially high-hazard locations, and (2) practical and effective standardized test methods for evaluation of devices. The National Bureau of Standards investigation reported herein addresses the two needs identified.

This study includes a systematic review of the literature, together with consultations and visits with water purveyors, plumbing officials, laboratory officials and researchers in this field. Emphasis has been placed on those devices, test methods, and laboratory practices considered most essential to an effective assessment of the state-of-the-art. Also, test development needs were identified in a few areas of greatest concern.

NBSIR 76-1072. **Back-up report for the proposed standard for the flammability of general wearing apparel,** E. Braun, V. B. Cobble, S. Helzer, J. F. Krasny, R. D. Peacock, and A. K. Stratton, 51 pages (June 1976). Order from NTIS as PB255446.

Key words: apparel; burn injury; ease of ignition; fabrics; fire; flammability tests; garments; heat transfer; standards.

A "Proposed Standard for the Flammability of General Wearing Apparel" was submitted to the Consumer Product Safety Commission in February 1976. This report discusses the reasons for the choices of experimental arrangement for the flammability test and the choices of pass-fail criteria. The specimen is cylindrical, to simulate a garment, and to eliminate framed specimens which often burn differently from garments. Criteria for the fire hazard of fabrics are the time to ignite with a specified gas flame and the heat transferred to sensors inside the burning specimen. The proposed standard specifies that fabrics which transfer little heat to the inside of the specimens could be used in all garments but would have to be used in garments which cover most of the body and/or fit loosely. They would also have to be used in children's dresses and skirts (children's nightwear is covered by an earlier standard). Fabrics which transfer larger amounts of heat, and thus have larger injury potential, could be used in garments with normal or tight fit such as most present-day shirts, slacks, etc. If such fabrics ignite in 1/2 second or less, they would be excluded from use in garments. These provisions in the proposed

standard were based on the need to reduce the number and severity of apparel fires with minimum economic and technological impact on the fiber, textile, and apparel industry. The present report summarizes the available knowledge in the area covered by the standard, and points out areas in which additional work is indicated.

NBSIR 76-1074. **Operation manual for 30,000 lbf constant-load testing machine,** D. E. Marlowe and W. H. Appleton, 31 pages (Oct. 1976). Order from NTIS as PB261497.

Key words: creep; instrumentation; stress rupture; testing machine.

A 30,000 lbf (133 kN) constant-load testing machine has been designed, and ten of these machines have been delivered to the NASA Langley Research Center. Each machine is equipped with a self-contained, closed loop load controller which is maintained at a constant temperature, independent of the external ambient conditions.

NBSIR 76-1076. **Flammability limits: Thermodynamics and kinetics,** A. Maček, 27 pages (May 1976). Order from NTIS as PB254180.

Key words: chemical kinetics; diffusion flames; flame extinction; flame temperature; flame velocity; flammability; flammability limits; oxygen index test; thermodynamics.

Extinction limits for both premixed and diffusion flames for n-alkanes and n-alcohols found in the literature are assembled. Several sets of theoretical flame temperatures corresponding to the limits are defined and presented. The implications of the view that flames fail to propagate at temperatures at which reaction rates become too low to overcome the dissipation processes are discussed. Equilibrium flame temperatures indicate that at lean limits the excess oxygen does not act merely as a diluent but takes an active part in promoting the kinetics of flame reactions. The burning-rate data and the results of ignition experiments are shown to be pertinent to the interpretation of flammability limits. Extinction characteristics of methane are shown to be atypical (compared to other alkanes and alcohols) and demand a special explanation. It is also shown that the assumption of thermodynamic equilibrium at the limits is unrealistic, so there is need for experimental temperature and concentration measurements in both premixed and diffusion flames. When the assumption of equilibrium is removed, the chemical kinetic considerations suggest a simple qualitative explanation of the limit phenomenon, based on the stipulation of incomplete combustion. Quantitative data are presented in support of this view.

NBSIR 76-1081. **Progress report on the corrosion behavior of selected stainless steels in soil environments,** W. F. Gerhold, E. Escalante, and B. T. Sanderson, 77 pages (Aug. 1976). Order from NTIS as PB256329.

Key words: coatings; corrosion behavior; field tests; galvanic couples; soil environment; stainless steels; stress-corrosion behavior.

In order to obtain more definitive information regarding the corrosion and stress corrosion of stainless steels in soil environments, NBS in cooperation with the Committee of Stainless Steel Producers, AISI, initiated in 1970 a soil burial program in representative soil environments. Test materials included coated and uncoated sheet specimens in the annealed and sensitized condition, uncoated welded tubing specimens and galvanically coupled and uncoupled stressed and unstressed specimens. To date approximately 10,000 specimens have been buried at six soil test sites. This report contains the results obtained for specimens buried for up to approximately four years.

NBSIR 76-1082. **A survey of State legislation relating to solar energy,** R. M. Eisenhard, 166 pages (Apr. 1976). Order from NTIS as PB258235.

Key words: architecture; buildings; design; energy; legislation; solar; State.

This report reviews enacted State legislation dealing with solar energy. Acts involving tax incentives, reduced property assessments, research and development, solar easements and solar energy promotion are identified and abstracted. The responsible State agency and official are listed. Acts and supporting forms and other information are included as appendices.

NBSIR 76-1083. **Report to AID on a Philippines survey on standardization and measurement services,** H. S. Peiser and R. S. Marvin, Eds., 124 pages (June 1976). Order from NTIS as PB255803.

Key words: building technology; information handling; measurement services; Philippines; standardization; testing facilities.

A survey of standardization and measurement services in the Philippines was carried out in May 1975 as part of a National Bureau of Standards Program sponsored by the Office of Science and Technology of the Agency for International Development. The Survey Team included five NBS staff members, one other U.S. participant, three third-country participants, and a number of Philippine specialists. The Survey was made under the direction of Mr. Vidalito F. Ranoa, Director of the Philippine Bureau of Standards.

The team was divided into five groups which concentrated on: Technical Standards Committee Management, Metrication, Building Technology, Technical Information Handling, and Testing Facilities. Each group made extensive visits to the governmental, academic, and private organizations and facilities relevant to their topic. In each area the report summarizes the existing situation, identifies current problems, and offers suggestions and recommendations for their resolution.

NBSIR 76-1084. **Nondestructive examination of glass-reinforced-plastic rod end fittings,** G. F. Sushinsky and L. Mordfin, 28 pages (Aug. 1976). Order from NTIS as PB257180.

Key words: end fitting; glass-reinforced-plastic rod end fitting; nondestructive examination; neutron radiography; ultrasonics; x-radiography.

An exploratory study was performed on the feasibility of using nondestructive examination techniques to detect voids in two types of potted compression end fittings. Four methods of nondestructive examination were tried: conventional pulse-echo ultrasonics, ultrasonic holography, x-radiography, and neutron radiography. The ultrasonic and x-ray methods that were tried proved unsatisfactory as a nondestructive examination tool for the two types of end fittings, and the neutron radiographic procedures successfully displayed the internal structure of only one of the specimen types. The procedures and results from the different methods of examination are summarized. Additional comments are given regarding the application of the methods to aluminum-jacketed specimens, and regarding improved methods for the inspection of steel-jacketed specimens.

NBSIR 76-1087. **On a scattered-light measuring device for use in testing types of smoke detectors,** M. Pistor, 35 pages (July 1976). Order from NTIS as PB257202.

Key words: fire detection; light extinction; light scatter; light-scatter measurements; photoelectric smoke detectors; smoke detectors.

Generally, the response threshold value of fire detectors is tested with measuring instruments which operate on the same physical principle as the detectors to be tested. For example, this means that the response threshold value of an ionization measuring chamber and the response threshold value of an optical-type smoke detector operating on a light extinction principle is checked using an extinction measuring instrument. However, optical-type smoke detectors operating on a light-scatter principle (photoelectric in U.S. parlance) have also been checked using an extinction measuring instrument.

Since the light-scatter type of smoke detector is by far the most commonly used of the optical type of smoke detector it seems appropriate to use a light-scatter measuring instrument to check the response threshold value of these detectors. In addition, the need for such a measuring instrument is emphasized by the fact that both the parameters of the smoke aerosol and the design features of the measuring instrument are affected in different ways by light scatter and light extinction.

The author describes the technical features and design details of a newly-developed, light-scatter measuring instrument along with some experiments to determine its response to artificially-generated aerosols.

NBSIR 76-1089. **An analysis of inertial seismometer-galvanometer combinations,** D. P. Johnson and H. Matheson, 205 pages (June 1976). Order from NTIS as PB254475.

Key words: accelerometer; calibration; electromechanical transducer; galvanometer; galvanometer amplifier; seismic system; seismometer.

This report develops the fundamental equations for an inertial seismometer with an electromechanical transducer. If the inductance as well as the resistance of the system are included, the equations of motion are of the third order. These are discussed in some detail. Response curves are developed for several seismometer-galvanometer combinations, some of which are suitable for telemetry. Techniques are discussed for calibration, both in the laboratory and in the field. Practical and theoretical limitations are treated for circumstances in which thermal agitation is a major source of instrumental noise. The bibliography includes lists of equivalent notations.

NBSIR 76-1090. **Environmental effects on microphones of various constructions,** G. R. Hruska, E. B. Magrab, W. B. Penzes, 36 pages (July 1976). Order from NTIS as PB255505, $4.00

Key words: calibration; ceramic; condenser; electret; humidity; microphones; reciprocity; sensitivity; temperature.

The pressure sensitivities of two "1/2-inch" electret, two "1-inch" ceramic, and two back-vented "1-inch" condenser microphones were measured for numerous combinations of temperature, percentage relative humidity, and frequency. The two condenser microphones were calibrated by the reciprocity technique at each combination of temperature, relative humidity and frequency. The condenser microphones were then used as calibrated sources to determine the pressure sensitivities of the other microphones. Insert voltage techniques were used to eliminate the environmental effects on the electronics. It was found that the back-vented condenser microphones are insensitive to changes in relative humidity. At frequencies considerably below their resonance frequencies they exhibited only a very small change in sensitivity with temperature. At frequencies closer to the resonance frequency the temperature coefficient increases approximately fourfold. The temperature and humidity coefficient for the electret and ceramic microphones could not be determined due to the instability in their sensitivities which produced changes that were larger than those induced by the temperatures and humidities.

NBSIR 76-1091. **Materials for fuel cells,** L. H. Bennett, M. I. Cohen, A. L. Dragoo, A. D. Franklin, and A. J. McAlister, 39 pages (May 1976). Order from NTIS as PB257768.

Key words: cerium dioxide; degradation; electrocatalysis; fuel cells; refractory hard metal; solid electrolytes.

This report describes the research plans and initial progress on the NBS program of research on Materials for Fuel Cells. Transition metal carbides, borides, and nitrides ("refractory hard metals," or RHM) are being examined as potential hydrogen oxidation electrocatalysts for use in acid fuel cells. Preliminary screening of 19 carbides and borides has revealed apparent stability in hot (up to 160 °C) phosphoric acid for TaB, MoB, NbC, TaC, Mo_2C, and WC. More sophisticated tests for acid stability for these materials are under way. Equipment for examination of the electrochemical behavior of these materials as hydrogen oxidation electrocatalysts in phosphoric acid electrolytes at temperatures up to 150 °C is being completed, and tests will be started on these materials shortly. Additional materials in the general RHM class, including a number of nitrides, have been ordered and will be screened for acid stability. More extensive exploration will be made of the properties of TaC and WC as a function of stoichiometry and presence of other metals and of oxygen. Plans exist for a parallel study of oxides as oxygen reduction electrocatalysts for acid fuel cells not under support of this project. The current effort is devoted to improving and expanding the facility for electrochemical measurements. The long-term stability of CeO_2-based solid electrolytes, which are promising new candidate materials for the high-temperature fuel cells, is under study. Materials for fabricating specimens of CeO_2 doped with Gd_2O_3 or Y_2O_3 have been obtained or ordered, and arrangements made to hot press them. Experiments have been designed to examine degradation of the electrical properties at temperatures from 500 to 1100 °C, with and without a constant current throughout the degradation anneals. Compositions will be chosen around those giving a maximum conductivity, and the oxygen partial pressure will be fixed at a convenient value. AC admittance measurements will be used to monitor the electrical properties. Furnaces and ancillary equipment are being assembled or constructed.

NBSIR 76-1093. **The application of test structures and test patterns to the development of radiation hardened integrated circuits: A review,** K. F. Galloway and M. G. Buehler, 15 pages (Aug. 1976). Order from NTIS as PB256318.

Key words: hardened integrated circuits; integrated circuits; radiation effects; radiation hardening; test patterns; test structures.

Government sponsored research and development on semiconductor devices intended for application in radiation environments often relies on test structures arranged into test patterns for device design information and process characterization. Problems unique to a radiation environment are often analyzed using test structures such as MOS capacitors and break-out transistors. The work reviewed in this report clearly demonstrates the importance of test structures in isolating and identifying problem areas. However, the measurement methodology associated with test structures is seldom reported which makes it difficult to compare the results of different workers. Also, the work reported to date using test structures and test patterns for assessing radiation effects has involved the relatively slow-speed laboratory testing of statistically insignificant numbers of test structures. Test patterns could be used by buyers of radiation hardened devices for (1) vendor selection and qualification, (2)

process validation for hardness screening and hardness assurance, and (3) identification of circuit parameters critical to hardness assurance. However, before this can effectively be done, it is necessary that standardized modular test structures be designed to measure parameters of known importance to device hardness, that statistically significant numbers of test structures be measured with high-speed integrated circuit testers, and that the data reduction and analysis routines be well established.

NBSIR 76-1095. **Properties and interactions of oral structures and restorative materials,** J. M. Cassell, 77 pages (Aug. 1976). Order from NTIS as PB255808.

Key words: adhesion; adsorption; alloys; composites; dental; grafting; investments; polymer; resin; wear.

A diversity of techniques is being directed toward development of new and improved dental restorative and caries-preventive materials. These have included: surface characterization of dental materials and coupling agent-coated hydroxyapatite by water adsorption; further evaluation of a novel testing approach for investigating the adhesive capability of coupling agents; synthesis of selected monomers for potential application as components of a dental composite restorative system or a pit and fissure sealant application; and investigation of techniques such as grafting with 2-cyanoacrylates and urethanes containing free isocyanate groups for modifying natural tooth and bone surfaces so as to achieve a more compatible surface for adhesion. Failure of the data acquisition and control system of a prototype pin on disc *in vitro* wear test procedure for dental restorative materials to record data consistently and to maintain proper measurement point trigger position have dictated construction of a new wear test unit that incorporates the successful design of the prototype unit, but that will allow for testing of multiple specimens and should permit data to be accumulated with a confidence level of 95 percent, as compared to the 90 percent level previously attained. Procedures have been developed for the investigation of nonprecious alloys used in crown and bridge application.

NBSIR 76-1096. **Guidelines for the determination and development of generic safety standards,** R. G. Hendrickson, 58 pages (Aug. 1976). Order from NTIS as PB257076.

Key words: management need; operations research—NS.

These guidelines were prepared to assist the CPSC in the development of generic safety standards. This development is based on conceptual models of product hazard interactions and analyses of accident sequences, product clustering, and hazard characteristics.

The motivation for these guidelines derives from a perceived need to expedite the standard development process and to enhance the efficiency of standards for consumer product safety.

NBSIR 76-1097. **Illustrative generic standard for the control of thermal burn hazards in household appliances,** R. G. Hendrickson, E. M. Robertson, and R. V. Kelly, 49 pages (Aug. 1976). Order from NTIS as PB257141.

Key words: burn hazards, household appliances; fault-tree diagrams; generic safety standards; household appliances; operations research; thermal burn hazards.

This document reports on the development of an illustrative generic standard for controlling hot surfaces associated with certain categories of consumer products. The development includes evaluations of accident data, fault-tree diagrams, theoretical heat-flow phenomena, current standards, and application of the thermesthesiometer as a test instrument.

This work is a companion to the Guidelines for the Development of Generic Safety Standards, and as such, it applies the methods and techniques provided in the Guidelines. The principal tool of analysis is the fault-tree method. This method brings to safety problems a versatile and insightful way of depicting events, conditions, and causes associated with hazards and accidents.

The intent is to demonstrate the feasibility of the generic approach to controlling safety aspects of consumer products. Although the illustrative standard is based on a study of actual data, the conclusions are not to be construed as final or authoritative.

NBSIR 76-1098. **Daylighting of buildings. A compendium and study of its introduction and control,** J. K. Holton, 39 pages (Oct. 1976). Order from NTIS as PB259523.

Key words: daylight gathering; daylighting of buildings; energy conservation; lenses; light conduits; light control; reflectors; skylights; windows.

We can no longer ignore daylight as a valuable natural resource for building illumination. Significant reductions in the energy consumption of buildings are possible by decreasing the dependence on artificial illumination and decreasing air conditioning loads by employing methods which bring in cool light. In order to design buildings utilizing daylight effectively there must be an understanding of the design principles of daylighting. This requires a knowledge of illumination to meet the needs of the building users, an understanding of characteristics of daylight at the location of the building, and imagination in developing ways to introduce and control daylight. This paper is directed toward the identification of innovative techniques for the introduction and control of daylight. It is arranged in three sections: a Compendium, a Study section, and a Reference section. The Compendium presents a number of state-of-the-art methods to assist the designer in successfully employing daylight more extensively. The Study section provides more detailed information on these methods so an increased understanding can be developed of those which appear to have suitability in a given situation. Finally, the References provide background for further investigation.

The Study organizes daylighting methods as they relate to three zones of a building, the perimeter, the intermediate and the deep zone. Each has different characteristics and is suited to daylighting by different methods.

NBSIR 76-1099. **Standardization and measurement services in Bolivia,** H. S. Peiser, R. S. Marvin, and J. Mejeur, Eds.. 105 pages (Sept. 1976). Order from NTIS as PB258612.

Key words: Bolivia; measurements; quality control; standardization; testing facilities.

A survey of standardization and measurement services available in Bolivia was carried out in June 1974 as part of a National Bureau of Standards program sponsored by the Office of Science and Technology of the Agency for International Development. The Survey Team included 4 NBS staff members, 3 third-country participants, and 11 leaders of technology and standardization in Bolivia. The Survey was made under the direction of Engineer Orlando Donoso Torrez, then the Director General of the Bolivian General Directorate of Standards and Technology.

After two days of joint activities, the Team was divided into three groups which visited various industrial, university, and government installations in the Cochabamba, Santa Cruz, and La Paz areas respectively. This report contains brief summaries of these visits and of the problems related to standards and measurements reported by the organizations visited. It also includes

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the results of a questionnaire distributed to most of the organizations visited in advance of the Survey.

A brief report of the conclusions and recommendations of the Survey Team is included in "Peiser, H. Steffen, and Marvin, Robert S., ed., Regional Seminar on a System of Standardization and Metrology for Latin America, NBSIR 76-988 (U.S.), 96 pages (1976)."

NBSIR 76-1100. **Appraisal of Federal Government Cobol standards and software management: Survey results,** D. R. Deutsch, 75 pages (June 1976). Order from NTIS as PB258371.

Key words: ADP; COBOL; Federal ADP installations; Federal Standard COBOL; impact evaluation; sample; software management; survey.

This report summarizes the results of a survey of selected Federal Government Automatic Data Processing (ADP) installations. Undertaken primarily as an evaluation of National Bureau of Standards (NBS) activities in support of the standardization of the COBOL programming language, the study also dealt with software management tools and practices.

The survey sample was selected from a subset of all known Federal Government ADP units; specifically, only domestic installations with at least one general purpose hardware system capable of supporting a modern COBOL compiler were included. Responses were received from over 70 percent of the 190 installations included in the sample.

The major portion of this document is made up of tabular summarizations of all responses for each survey question. Gross statistics and frequency distributions are presented on a question-by-question basis. No interquestion relationships are analyzed. The appendices include a comprehensive discussion of the sampling methodology and survey mechanics and a reproduction of the survey instrument with cross references to response tabulations appearing in the report.

NBSIR 76-1102. **Computer programs for structural chemistry: STATUS. A FORTRAN program for statistical analysis of crystallographic quantities,** L. W. Schroeder and B. Dickens, 152 pages (July 1976). Order from NTIS as PB257729.

Key words: crystallographic data; errors; probability plots; residuals; statistics; uncertainties.

This report describes a FORTRAN computer program for evaluation of (i) the results of crystallographic least-squares refinements by examination of the residuals, (ii) differences in sets of data collected by different methods from the same crystal, (iii) differences in data sets collected by the same method from different crystals of the same material, and (iv) the differences in parameters in different models representing the crystal structure of the same material.

Part of the evaluation is accomplished by plots of residuals against the expected normal distribution quantiles. Additional plots compare residuals with the independent variable, d*, and with the calculated variable $Fc^2/\sin 2\theta$. The Miller indices can be used to divide a data set into various classes and octants so that the possibility of anisotropic effects can be examined.

The program will treat up to 7200 data points in each of two experimental data sets or 1000 structural parameters, and is oriented specifically towards examining crystallographic data.

NBSIR 76-1107. **Considerations in developing test methods for protective headgear,** R. E. Berger, 55 pages (Aug. 1976). Order from NTIS as PB258322.

Key words: head injury; helmets; math model; protective headgear; safety; test methods.

The purpose of this report is to outline the relationship between test methods for protective headgear and injury prevention. The state-of-the-art concerning the mechanisms of head injury and the relationship of these injuries to the modes of energy input are briefly reviewed. The general guidelines in the design of protective headgear are discussed, and the difficulties with present test methods for helmets are summarized.

In order to provide a quantitative framework, a simple model which incorporates many features of present test methods is defined and executed. The model predicts the effect of changes in test method parameters (headform, impact surface, drop height) for a range of helmet parameters. Among the indications suggested by the model are: 1) the occurrence of reversals in the order of helmet performance when the maximum acceleration is used as a performance measure, 2) the absence of reversals when biomechanical measures are used, and 3) the indicated suitability of compensating for the resiliency of the headform by the resiliency of the impact surface.

NBSIR 76-1109. **Architectural glazing safety standard: Survey of codes and standards,** S. C. Adler, 65 pages (Aug. 1976). Order from NTIS as PB257194.

Key words: architectural glazing; codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law.

The report describes 34 test procedures extracted from 97 codes and standards identified in an extensive library search of English language codes and standards relating to architectural glazing. The report also contains summaries of existing state laws relating to safety glazing. Test descriptions include procedures, kinetic energy levels, purpose of tests, and acceptance/rejection criteria. Test methods, codes and standards, and sources are cross-referenced.

NBSIR 76-1110. **The acoustic pressure field alongside a manikin's head with a view towards *in situ* hearing aid tests,** E. D. Burnett and G. F. Kuhn, 26 pages (Aug. 1976). Order from NTIS as PB257073.

Key words: audiometry; diffraction; head diffraction; hearing aids; instruments for hearing; manikin.

To simulate actual usage conditions, the frequency response of hearing aids was measured on the head of a manikin over the frequency range of 0.2 to 8 kHz. The acoustic pressure around the head can vary rapidly as a function of frequency and location. In order to compare and interpret the hearing aid response at various frequencies and locations on the head, it is necessary to precisely know the pressure variations. The amplitude and phase of the acoustic pressure were measured in increments ranging from 2 mm to 5 mm alongside a manikin's head with frontal sound incidence. The acoustic driver was located in front of the manikin at a distance of 1.0 m from the ear canal axis. The test frequencies were the octave band center frequencies from 0.5 kHz to 4.0 kHz and the third octave band center frequencies from 4.0 kHz to 8.0 kHz. It will also be shown that pink noise of 6 percent and 29 percent bandwidth at 6.3 kHz and 8.0 kHz has a smoothing effect on the acoustic pressure variation with location.

NBSIR 76-1112. **Technical assessment of safety for hair dryer/stylers,** Y. C. Wu, 36 pages (Sept. 1976). Order from NTIS as PB259636.

Key words: air flow rate; electrical, mechanical and thermal hazards; hair dryer/stylers; heat flux; safety; technical analysis; temperature.

The handheld dryer/styler is an efficient and popular small appliance, but a high injury trend associated with such products has been reported. Hazards commonly associated with the product are electrical, mechanical and thermal. In this study, the relation between these hazards and human tolerance limits were analyzed and experiments to investigate the probable cause and potential of such hazards were conducted. Randomly selected samples of the product were subjected to relevant safety performance tests of the UL Standard 859. In addition, air flow rate, heat flux and surface temperature were measured on several samples in order to determine their thermal hazard potential. Based on the results of these investigations, corrective measures are suggested.

NBSIR 76-1115. **Optical materials characterization,** A. Feldman, D. Horowitz, R. M. Waxler, and M. J. Dodge, 20 pages (Aug. 1976). Order from NTIS as PB257196.

Key words: BaF_2; CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; refractive index; thermal coefficient of refractive index; thermal expansion coefficient; ZnSe.

The refractive index of a sample of hot-forged CaF_2 was measured from 0.25 μm to 8.0 μm by means of the minimum-deviation method on a precision spectrometer. Data were obtained near 20 and 34 °C. Each data set was fitted to a three-term Sellmeier-type dispersion equation, which permits interpolation of refractive index as a function of wavelength within a few parts in 10^5. With the index values obtained at the two temperatures, the change in index with temperature was calculated. The refractive index and values obtained for this specimen are compared with data previously published. Two new experimental arrangements have been constructed for the interferometric measurement of the thermal coefficient of refractive index, thermal expansion, and piezo-optic constants. The first permits measuring dn/dT and thermal expansion from -180 to $+200$ °C. The second is a highly stable and sensitive interferometer for measuring photoelastic constants in the visible, the near infrared, and the near ultraviolet. Thermal expansion data are obtained on CVD ZnSe, CaF_2 and BaF_2 between -100 and $+120$ °C and fitted to a third degree polynomial in temperature. We obtain dn/dT for CVD ZnSe at 632.8 nm over the same temperature range. The piezo-optic constants of fused silica and CVD ZnSe obtained with the new interferometer at 632.8 nm are in excellent agreement with values obtained by other methods.

NBSIR 76-1120. **Fire research publications, 1975,** N. H. Jason, 17 pages (Sept. 1976). Order from NTIS as PB257837.

Key words: bibliographies; building fires; construction materials; fire departments; fire detection system; fire tests; flame detectors; flammability tests; hazard analysis; interior furnishings; toxicity.

"Fire Research Publications, 1975" is a supplement to the previous editions which covered the years 1969-1972(NBSIR 73-246), 1973 (NBSIR 74-511) and 1974 (NBSIR 75-736). Only publications prepared by the members of the Center for Fire Research (CFR), by National Bureau of Standards (NBS) personnel or external laboratories under contract or grant from the CFR are cited. Articles published in NBS house organs also are cited.

NBSIR 76-1124. **Evaluation system proposal preparation and evaluation procedure,** C. W. N. Thompson, 89 pages (Feb. 1976). Order from NTIS as PB261846, $5.00

Key words: evaluation systems; Experimental Technology Incentives Program; procurement experiments; procurement procedures; proposal evaluation procedures; proposal preparation procedures.

As part of its program with respect to the conduct of procurement experiments, the Experimental Technology Incentives Program of the National Bureau of Standards developed an integrated set of documents to provide information for use by both bidders and the proposal evaluation team in the procurement of two evaluation systems. The set of documents includes the following: (1) Introductory Notes; (2) Some Definitions; (3) Proposal Preparation Procedure (with revisions); (4) Evaluation System Design Process; (5) Statement of Work; (6) Statement of Work (with illustrative subitems for Phase One); (7) Proposed Schedule—Overall; (8) Proposed Schedule—Phase One; (9) Proposal Evaluation Factors; (10) Proposal Evaluation Factors (with Illustrative Questions); (11) Numerical Weights for Proposal Evaluation Factors; and (12) Scope of Effort. Except for introductory and descriptive material, all of the documents are organized on the basis of seven factors (and thirty-three subfactors) to facilitate both preparation and evaluation of proposals. Each subfactor measures the bidder's understanding, present or proposed approach, and present or potential capability to perform with respect to an important problem or characteristic of the program. While the procedure is considered limited to certain systems and related procurements, it is considered a significant departure from prior procedures.

NBSIR 76-1126. **Field investigation of residential smoke detectors,** R. W. Bukowski, 53 pages (Nov. 1976). Order from NTIS as PB260878.

Key words: detector sensitivity; detector siting; escape time; fire tests; heat detectors; residential fires; smoke detectors.

A test program was undertaken to evaluate the effect of sensitivity and placement of residential smoke detectors on their response to fires in homes. The tests were conducted in two homes scheduled for demolition and used actual furnishings in typical configurations. In addition to the detector response times, the homes were highly instrumented with data on smoke, temperature, and gas concentration measured for all tests.

The tests showed that smoke detectors can be highly effective in providing adequate warning of a fire before conditions in the home become dangerous.

NBSIR 76-1130. **Program and abstracts. Symposium on nonbiological transport and transformation of pollutants on land and water: Processes and critical data required for predictive description, May 11-13, 1976, National Bureau of Standards, Gaithersburg, MD,** L. H. Gevantman, Ed., 199 pages (May 1976). Order from NTIS as PB257347.

Key words: adsorption; nonbiological transformation; nonbiological transport; pollutant photochemistry; pollutants; soil pollution; solar spectrum; water pollution.

Program, abstracts and extended abstracts of 21 papers presented at a symposium on nonbiological transport and transformation of pollutants on land and in water are documented. Most of the extended abstracts are detailed and contain figures and references to pertinent literature on the subject matter discussed at the symposium. The subject matter reviewed deals with the physical and chemical behavior of pollutants, including pollutant photochemistry, adsorptive behavior of pollutants, hydrolysis, rates of pollutants, and mathematical models for documenting pollutant behavior in soils and water.

NBSIR 76-1131. **A model performance standard for guardrails,** S. G. Fattal, L. E. Cattaneo, G. E. Turner, and S. N. Robinson, 31 pages (July 1976). Order from NTIS as PB259242.

Key words: design; dynamic loads; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; static loads; stiffness; structural safety.

A model performance standard and design illustrations are presented for the design, construction and evaluation of guardrail systems, which will be used for the protection of employees against occupational hazards. The standard stipulates both structural and nonstructural safety requirements. Each criterion includes a commentary section describing the rationale used in its formulation. This rationale is for the most part, based on independent experimental and analytical research investigations conducted at NBS in behalf of OSHA.

NBSIR 76-1132. **Personnel guardrails for the prevention of occupational accidents,** S. G. Fattal, L. E. Cattaneo, G. E. Turner, and S. N. Robinson, 80 pages (July 1976). Order from NTIS as PB260363.

Key words: anthropometric measurements; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; structural safety.

Existing information is compiled which would assist in determining structural and nonstructural safety requirements for guardrails used for the protection of employees against occupational hazards. Critical aspects of guardrail safety are identified through exploratory studies consisting of field surveys of prototypical installations, reviews of existing standards and industrial accident records, and compilation of relevant anthropometric data. These exploratory studies will be utilized to design an experimental program which will consist of structural tests to determine design loads and nonstructural tests to determine geometric requirements for guardrail safety.

NBSIR 76-1133. **Skid resistance measurement tests of FHWA reference systems at the Western Field Test Center,** R. W. Kearns and J. F. Ward, 167 pages (Oct. 1976). Order from NTIS as PB261228.

Key words: accident reduction, skidding; correlation, skid resistance; highway safety; measurement, skid resistance; pavement, skid resistance; pavement wetting system; tire-pavement interface forces; wet pavement.

The Federal Highway Administration (FHWA) is developing a program to improve the method of measuring wet weather pavement skid resistance (SN) and to reduce the variation in results. At the national level, an interim reference system (IRS) is maintained and operated by the National Bureau of Standards. At the regional level, an area reference system (ARS) is maintained and operated at each FHWA field test center. Intercomparisons between these reference systems and the highway measuring systems at the state level, provide measurement assurance.

In this report, the first correlation results between the IRS and the Western ARS (WARS) are given: $SN_{WARS} = 4.55 + 0.99\ SN_{IRS}$ where the computed standard deviation of a mid-range predicted value is 1 SN. SN is described as a function of test speed, V, in mph (1 mph = 1.609 km/h): for surface 2; $SN(V) = 76.5 - 0.71 + 0.0070V^2$ and the speed gradient is $d(SN)/dV = -0.71 + 0.014\ V$.

The test program is explained from test preparations, tuning and calibration of subsystems, through dynamic measurement of the surfaces. Controlled and uncontrolled variables are identified, discussed, and in some cases, experimentally verified. A ranking of the sources of dispersion is given. A discontinuity in SN of surface 1 is identified due to the unique test plan. A ground station for improved SN calculation precision and on-site statistical analysis is found to meet design objectives.

NBSIR 76-1136. **Failure analysis of fiberglass insulator rods,** L. Mordfin and N. Halsey, 57 pages (July 1976). Order from NTIS as PB261965.

Key words: breakdown, electrical; failure analysis; fiberglass-reinforced plastics; flammability; guy insulators; high-voltage tests; insulators, tower guy; Loran C; pultruded rods; rods, insulator.

Failure analyses were carried out on a group of coated fiberglass-reinforced-plastic insulator rods that had sustained burn damage and loss of coating in service on a radar tower. The investigation included chemical, flammability, electrical and mechanical tests as well as a variety of measurements and inspections. The burn damage, consisting chiefly of carbonaceous tracking and charring, was attributed primarily to the occurrence of electrical discharges, from the energized end fittings to the rods, under conditions in which the electrical leakage path resistance had been reduced by moisture from rain, fog and ocean spray. The effects of this damage on the structural integrity of the rods were evaluated. Recommendations were made for reducing the incidence of such damage in the future, based on the use of skirted insulator rods or more effective coating materials. The principal cause of the coating loss was not positively identified. This form of damage was not found to have serious consequences except as a secondary factor which may have contributed to the occurrence of some partial electrical discharges.

NBSIR 76-1137. **Thermal data requirements and performance evaluation procedures for the national solar heating and cooling demonstration program,** E. Streed, M. McCabe, D. Waksman, J. Hebrank, and T. Richtmyer, 86 pages (Aug. 1976). Order from NTIS as PB257770.

Key words: data requirements; measurement uncertainty; solar energy systems evaluation; thermal performance.

This report presents the results of a study to determine the data requirements and performance evaluation factors to be used in the National Solar Heating and Cooling Demonstration Program. Solar energy systems used for heating hot water, space heating, and space cooling have been considered and specific measurements and analytical procedures have been recommended to determine the thermal effectiveness for daily, monthly, seasonal, or annual operating periods. The sensor accuracy and sampling rate effects on measurement uncertainty for several performance factors is presented. Application of the individual performance factors for the comparison of subsystem and system thermal performance as a function of building type and climatic region is discussed.

NBSIR 76-1138. **A proposed experiment to evaluate environmental dependence of the measurement of noise from medium and heavy duty trucks,** C. I. Holmer and R. D. Kilmer, 68 pages (Sept. 1976). Order from NTIS as PB259522.

Key words: acoustics; environmental conditions; noise measurement; noise (sound); transportation noise; truck.

Increasing concern with the impact of transportation noise on communities has led to an increase in the number of motor vehicle noise regulations at all levels of government. As regulations become more widespread, the accuracy and precision of vehicle noise measurements become more critical since each uncertainty in the measurement requires a corresponding increase in the margin that manufacturers must allow between the regulated noise limit and vehicle design levels. Although considerable uniformity has been achieved by existing voluntary standards,

there remain significant variations between noise measurements made at different sites or at different times on the same site. These variations are attributable to differences in the environment, including site and meterological influences. Thus, there is a need for systematic investigation of the various environmental and test site effects on noise generation, radiation and/or propagation. This report presents the findings of a feasibility study for an experiment to investigate environmental effects on truck noise emission measurements. The result of this study is a proposed experiment designed to examine the systematic and nonsystematic dependence of observed truck driveby noise on the environmental effects present during the measurement. The experiment is designed in such a manner as to permit separation of emission and propagation effects. Although it may not be feasible to determine "correction factors" for environmental effects within the time and financial constraints of this experiment, it is fully expected that the data obtained from this experiment will reveal the magnitude of variations in the measurement and provide a broad enough information base for study of the underlying physical mechanisms.

NBSIR 76-1140. **Standards referenced in selected building codes,** B. M. Vogel, 447 pages (Oct. 1976). Order from NTIS as PB259626.

Key words: building codes; building regulations; building regulatory system; standards.

This publication provides a compilation of the standards that are referenced in the building codes promulgated by: (1) the three model building code organizations; i.e., Building Officials and Code Administrators International, Inc. (BOCA); International Conference of Building Officials (ICBO); and the Southern Building Code Congress International, Inc. (SBCC); (2) the twenty States that have either mandatory or voluntary building codes; and (3) the thirty largest U.S. cities. In addition to identifying each standard referenced in the above named codes, this publication lists the current date of the standard, its current title, the codes referencing it, the date of the code, the locations within the code where the standard is referenced, and the date of the standard referenced in the code. This publication is intended to provide a base for assisting the building community in updating, utilizing and maintaining the standards referenced in building codes.

NBSIR 76-1141. **Study of initial stages of wear by electron channeling. I. Measurement of plastic strain in copper due to sliding wear, II. Quantitative methods in wear debris analysis,** A. W. Ruff, 53 pages (Sept. 1976). Order from NTIS as ADA031530.

Key words: copper; electron channeling; electron microscope; metals; particle analysis; plastic deformation; surfaces; wear; wear debris; x-ray analysis.

Wear experiments have been conducted to determine the plastic strains that are introduced in the surface material near sliding wear tracks. Both oil lubricated and dry sliding experiments have been carried out at different sliding distances on surfaces of copper. The strain values were determined from selected area electron channeling patterns obtained using a scanning electron microscope from regions as small as 10 μm in size and 0.05 μm deep around the wear track. A deformed calibration specimen was used to relate electron channeling band contrast to deformation strain. Strain maps were obtained on the wear surface lateral to the wear track and also below the surface using electropolishing metal removal techniques. Particular attention was placed on the near-surface strain values. In all cases, the maximum strain was found at the wear surface located at the track center and the strains decreased uniformly with depth. Significant, large strains were also found outside the wear tracks. The results are compared with those previously reported for iron and with recent theoretical models.

Wear debris has been removed from a number of test systems and analyzed using different methods. Those methods produced specific information concerning the particulate size and composition. A magnetic debris recovery method was quantitatively evaluated using actual debris samples and also using collections of manufactured particulates having known sizes and compositions. Small 5 μm diameter SiO_2 spheres, some containing nickel, were used to simulate debris. Other particulates of iron and nickel in different size ranges were also used in order to investigate such matters as size resolution, lubricant dilution techniques, particle overlap difficulties, and the general problem of calibration of debris recovery systems. A comparison between chemical analysis and particulate analysis findings is presented. The application of optical and electron microscope methods and x-ray microanalysis in characterizing the wear particulates was carried out directly on the recovery substrate; those techniques are described.

NBSIR 76-1142. **Considerations and standards for visual inspection techniques,** G. T. Yonemura, 17 pages (Oct. 1976). Order from NTIS as PB263099.

Key words: nondestructive testing; modulation transfer function; vision; visual acuity; visual capacities.

When we look at the capacity of the human visual system we see that it has many capacities depending on the circumstances under which it is used. The sensory data show that man can adjust to a wide variety of operating conditions. But, unless we have detailed information of the conditions for which these processes are to be optimized and quantitative descriptions of the tasks to be performed, the advantages to be obtained by visual science applications cannot be optimally utilized. Physical correlates of the response should be quantified, followed by a systematic scaling of the physical correlates for application to nondestructive testing. The Modulation Transfer Function widely used in optical imaging assessments would be an evaluation technique applicable to hardware, processing and image description.

NBSIR 76-1143. **Plan for the development and implementation of standards for solar heating and cooling applications,** D. Waksman, J. H. Pielert, R. D. Dikkers, and E. R. Streed, 55 pages (Aug. 1976). Order from NTIS as PB257769.

Key words: buildings; solar energy; standards.

A plan is presented concerning the need, implementation and general scope of standards which may be required for solar heating and cooling applications. Overviews of the building regulatory system in the United States are given along with a listing of the various standards which will be required for the various solar systems, subsystems, components and materials. These include Test Method Standards, Recommended Practice Standards and Specification Standards. Activities relative to standards implementation include laboratory accreditation, certification, training and manuals of accepted practice. The development of standards for solar applications by the Federal Government are outlined, as well as the potential interface and utilization of the existing consensus standards generating organizations.

NBSIR 76-1144. **NBS interagency transducer project—Progress report No. 5,** J. S. Hilten, C. F. Vezzetti, J. F. Mayo-Wells, and P. S. Lederer, 26 pages (Nov. 1, 1976). Order from NTIS as PB259243.

Key words: coatings; dynamic; dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift.

Experimental efforts are described in the development and evaluation of means to reduce the effects produced by thermal radiant-energy transients on pressure-transducer response. Both unbonded strain-gage and piezoelectric pressure transducers were used in this work with protective coatings applied directly to the diaphragms. The test method employed is to expose a pair of transducers—one protected and the other unprotected, but otherwise nominally identical—to a known radiant-energy transient with an energy density of approximately 20 mJ/mm^2. The resulting zero shift is measured and taken as an index of coating effectiveness.

The effect of the presence of the coating on transducer dynamic response was investigated by means of a shock tube, with a protected and an unprotected transducer pair exposed to the same pressure step of approximately 280 kPa (40 psi). Each transducer output was recorded as a function of time.

Test results with nine coatings and two transducer pairs are presented.

NBSIR 76-1147. **A combined least sums and least squares approach to the evaluation of thermodynamic data networks,** D. Garvin, V. B. Parker, D. D. Wagman, and W. H. Evans, 41 pages (July 1976). Order from NTIS as PB259637.

Key words: computerized data analysis; data evaluation; least squares (L2); least sums (L1); thermochemistry; thermodynamic data networks.

A description is given of a system for computer-based evaluation of interrelated thermodynamic measurements of enthalpies of reaction, equilibria and entropies. This system is an extension of the CATCH program developed by J. B. Pedley, University of Sussex. In the new system linear least sums and least squares techniques are used to solve networks of thermodynamic equations to obtain the enthalpies and free energies of formation and the entropies of chemical substances. The least sums technique is shown to be useful in assessing the consistency of the data. A method combining least sums and least squares solutions, provides a weighted solution that reproduces closely the solutions that are obtained by a detailed analysis of the data using the customary sequential procedure. The results from tests on four large networks involving compounds of B, U, Rb and salts of Sn, Pb, Cd and Hg are discussed.

NBSIR 76-1153. **Microstructural aspects of deformation and oxidation of magnesia-doped silicon nitride,** N. J. Tighe, 11 pages (Sept. 1976). Order from NTIS as PB259638.

Key words: cristobalite; deformation; electron microscopy; microstructure; oxidation; silicon nitride; slow crack growth enstatite.

The microstructural changes that occurred in magnesia-doped silicon nitride as a result of slow crack growth, plastic deformation and oxidation were studied by transmission electron microscopy. Specimens which exhibited slow crack growth showed extensive crack branching along the fracture path and ahead of the primary crack tip. These primary and secondary cracks followed intergranular paths. In samples which were deformed by bending at 1400 °C, dislocation arrays were found as well as intergranular cracks and voids. Silicon nitride oxidized during heating in air at 1400 °C and enstatite and cristobalite were present in the oxide layer. At lower oxidation temperatures, crystalline and amorphous silica formed a semiprotective layer on the silicon nitride surfaces.

NBSIR 76-1154, Vol. 1. **Consideration of fracture mechanics analysis and defect dimension measurement assessment for the Trans-Alaska Oil Pipeline girth welds,** H. Berger and J. H. Smith, Eds., 183 pages (Oct. 18, 1976). Order from NTIS as PB260400.

Key words: fracture control; fracture mechanics; mechanical properties; nondestructive evaluation (NDE); radiography; welding.

In anticipation of a request for waivers on defective girth welds in the Trans-Alaska oil pipeline, DoT requested assistance from the National Bureau of Standards (NBS) in evaluating the fracture mechanics analysis and the nondestructive evaluation (NDE) methods used to detect and determine dimensions of weld defects.

NBS measured the required mechanical properties of the weld metal, developed and evaluated fracture mechanics methods to determine the allowable defect sizes, and evaluated various methods of measuring the size of defects present in the welds from existing field radiographs.

Results of this investigation show that the fracture mechanics analysis can be used to determine the allowable defect sizes concerning the integrity of the pipeline, but that these analyses have not been experimentally verified at this time. Defect dimensions can be determined with sufficient accuracy to be useful in the fracture mechanics analyses if the radiographs are made under carefully controlled conditions. If the radiographs are not made with close control, the accuracy of the defect sizes may not be sufficient to permit their use in establishing allowable defect sizes.

NBSIR 76-1154, Vol. 2. **Consideration of fracture mechanics analysis and defect dimension measurement assessment for the Trans-Alaska Oil Pipeline girth welds,** H. Berger and J. H. Smith, Eds., 135 pages (Oct. 18, 1976). Order from NTIS as PB260401.

Key words: fracture control; fracture mechanics; mechanical properties; nondestructive evaluation (NDE); radiography; welding.

In anticipation of a request for waivers on defective girth welds in the Trans-Alaska oil pipeline, DoT requested assistance from the National Bureau of Standards (NBS) in evaluating the fracture mechanics analysis and the nondestructive evaluation (NDE) methods used to detect and determine dimensions of weld defects.

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NBSIR 76-1159. **Fatigue and weatherability studies of aramid-fiber rope slings,** N. Halsey and L. Mordfin, 35 pages (Sept. 1976). Order from NTIS as PB261994.

Key words: aramid fiber rope; breaking load, rope; cable, aramid-fiber; end fittings, rope; fatigue damage; rope, aramid-fiber; slings, cargo; terminations, rope; weathering, simulated.

Tests were carried out on twenty-six sling-leg specimens, fabricated from aramid-fiber ropes, as part of a program to develop improved external cargo slings for helicopters. The ropes included both parallel-strand and cabled-strand varieties, in three different tensile capacities. The tests were intended to evaluate the reductions in rope strength caused by fatigue loading and by exposure to simulated weathering. It was found that the fatigue capabilities of some of the ropes may not be entirely satisfactory; but, because of inadequacies in the end fittings installed by the rope manufacturers, thorough evaluations were not possible. The results indicate that the performances of the ropes could be enhanced through the use of more efficient end fittings, and suggestions for the development of such end fittings are offered.

NBSIR 76-1162. **FY 1975-1976 international building research activities, Center for Building Technology,** S. G. Webber, 67 pages (Nov. 1976). Order from NTIS as PB260879.

Key words: building research; cooperative programs; information exchange; international building research; international organization memberships; special foreign currency programs.

This report documents international building research activities of the Center for Building Technology (CBT) during Fiscal Year 1975 and 1976 (July 1, 1974-June 30, 1976). CBT carries out extensive interactions with foreign and international research organizations to exchange building research efforts. This report presents a summary of CBT's cooperative programs in building technology, international organization memberships, exchange programs, information exchanges, and foreign visits to NBS.

NBSIR 76-1172. **A new test method for automatic fire detection devices,** R. G. Bright, 29 pages (Dec. 1976). Order from NTIS as PB261217.

Key words: fire detector; test methods.

An analysis of the test methods for automatic fire detection devices in the U.S. reveals the fact that different types and different sizes of fires are used to evaluate different classes of detectors. The result is a lack of comparison test data for each detector class and, as a consequence, intelligent decisions cannot be made in the selection of automatic fire detectors for specific fire risks. A new test method is proposed in which all automatic fire detectors, regardless of sensor type, would be subjected to a series of the same test fires. In addition, each test fire series would consist of three different test fire sizes. From the results obtained, it should then be possible to match a detector's characteristics against a specific fire risk resulting in a more intelligent application of automatic fire detectors.

NBSIR 76-1176. **Regional seminar on OMNITAB II,** D. Hogben and S. T. Peavy, 27 pages (Dec. 1976). Order from NTIS as PB261995.

Key words: acceptance tests; AID; Bolivia; CENACO; computing using Spanish; foreign relations; international agreement; lectures; OMNITAB II computing system; technology transfer; terminals.

The authors visited La Paz, Bolivia, from May 11 to May 26 to conduct an AID Regional Seminar on applications of the OMNITAB II computing system. A Spanish, interactive version of OMNITAB II was implemented on the CENACO DEC-10 system computer. From May 17 to 22, lectures were given to thirty participants from five Latin American countries and sessions were held for the participants to gain experience in the use of OMNITAB II from terminals. At the beginning, the computer was not being used; at the end, OMNITAB II was being used extensively to solve important problems. An international agreement was signed by participants from the Latin American countries to cooperate in the utilization of computers.

NBSIR 76-1187. **Interim performance criteria for solar heating and cooling systems in commercial buildings,** 100 pages (Nov. 1976). Order from NTIS as PB262114.

Key words: buildings; cooling; heating; hot water; performance criteria; solar energy; standards.

Public Law 93-409, the Solar Heating and Cooling Demonstration Act of 1974, provides for "demonstration within a three-year period of the practical use of solar heating technology, and .... the development and demonstration within a five-year period of the practical use of combined heating and cooling technology." Under the provisions of the Act, in February 1975, the NASA developed a first edition of this document containing interim performance criteria for the design and evaluation of solar heating and cooling systems to be demonstrated in commercial buildings. Since that time, responsibility for further development of the document has been assumed by the NBS. This second edition of the "commercial criteria" represents the first revision to the NASA document. It is expected that this document will be updated periodically as data and information are gained from the demonstration program.

3.16. GRANTEE/CONTRACTOR REPORTS AND NBS PATENTS

Grantee/contractor reports are prepared by non-NBS persons or organizations working under grant or contract from the National Bureau of Standards. Those contract reports not incorporated into the formal NBS publication series are available directly from the National Technical Information Service (NTIS, Springfield, VA 22161) in paper copy or microfiche form unless otherwise stated. When ordering a report from NTIS you must order it by the "COM, PB, AD, or N" number as indicated.

Patents—legal documents which fully describe inventions in return for the right for 17 years to exclude others from making, using, or selling the inventions—are obtained on NBS inventions of high commercial potential, in order to establish Government ownership of the patent rights. The patents are then made available for the grant of nonexclusive licenses to all qualified applicants. A limited exclusive license may be granted under a particular patent, however, if it appears that some period of exclusivity is necessary as an incentive for the investment of risk capital. For information on licensing any of the patents, write to the Office of the Legal Adviser, National Bureau of Standards, Washington, DC 20234. Copies of patents may be obtained from the U.S. Patent and Trademark Office, Washington, DC 20231 for 50 cents each.

NBS-GCR-73-1. **Characterization of bedding and upholstery fires,** C. A. Hafer and C. H. Yuill, 46 pages (Mar. 1970). Order from NTIS as PB192365.

Key words: bedding; beds; carbon dioxide; carbon monoxide; combustion products; fire gases; fire hazards; furniture; life hazard; oxygen; smoke; temperature; toxicity; upholstery.

Many accidental deaths are attributed to fires started from smoking in bed or in upholstered chairs. Frequently, the victims die as a result of exposure to smoke, heat, or noxious fumes that develop as materials burn rather than from skin burns. The objective of this program was to conduct full-scale tests using bedding and upholstered furniture to determine the life hazards that may be present during fires starting with a small ignition source.

Thirty individual tests were conducted using various combinations of materials. The ease of ignition of bedding and upholstery was demonstrated and the pattern of development of smoke, heat, noxious gases, and oxygen depletion was recorded.

NBS-GCR-73-2. **Fabric flammability test development,** W. R. Brown and F. A. Vassallo, 87 pages (May 1970). Order from NTIS as PB194614.

Key words: fabric flammability; flammability testing; heat transfer; smoldering fabrics.

Heat meter instrumentation and a test chamber are developed for the measurement of heat transfer from burning and smoldering fabrics. The meters yield a signal proportional to heat flux, and a four-channel electronic integrator provides total heat input data as a function of time. Literature data on skin damage vs. heat input are employed in a graphical overlay method of interpreting data in terms of skin damage. Data demonstrating good reproducibility in tests of cotton fabrics at various spacings are presented. Thermoplastic fabrics tended not to burn or smolder regularly in the flat panel form employed in the test, but recommendations are given for study of strip specimens which may be amenable to test by the suggested methods. It was found that all of the fabric specimens which burned regularly in the chamber produced heat inputs at least double those required to inflict second-degree burns.

NBS-GCR-73-3. **Conversion of scientific and technical resources economic challenge—Social opportunity,** E. R. Mottur, 204 pages (Mar. 1971). Order from NTIS as COM 71-00605.

Key words: economic challenge; scientific and technical resources, converting; social opportunity.

This excerpt from the forthcoming overall project report describes the economic challenge and social opportunity presented by conversion of scientific and technical resources, and sets forth 26 policy proposals as a national program for conversion.

The report is concerned solely with conversion of the nation's scientific and technical resources, including manpower (scientists, engineers, technicians, support personnel, and technical management), facilities and equipment, and scientific and technical information. Conversion of scientific and technical resources from the defense sector must be to civilian R&D aimed at ameliorating national social problems.

Need for Conversion: About 100,000 scientists, engineers, and technicians are currently unemployed. About 200,000 (one out of ten technical personnel in the nation) are likely to be unemployed by the end of 1971.

Need for National Program: Report contends conversion can succeed only through cooperation of Federal, State, and local governments, with private industry, universities, and the scientific and technical community; with strong federal leadership.

Existing conversion programs and proposals are reviewed and characterized as essentially job-placement activities. Conversion bills pending in Congress are also analyzed.

NBS-GCR-73-4. **The influence of fine structure on the pyrolysis and combustion of cellulosics,** M. Lewin and A. Basch, 62 pages (1972). Order from NTIS as COM 73-10323.

Key words: cellulosic fibers; combustion; cotton fibers; flame retardant treatments; phosphorous acids; pyrolysis; ramie; rayon; sulfur.

A series of cellulosics comprising cottons, ramies and rayons differing in degrees of crystallinity and orientation were purified, characterized and pyrolyzed in vacuum and in air at low and high temperatures. The kinetics of the low temperature pyrolyses were studied and activation energies were derived by dynamic TGA. The rates of the low temperature pyrolyses in both vacuum and air are shown to be dependent upon the crystallinities and orientations of the cellulosics. In addition, the rates of vacuum pyrolysis are also a function of the D.P., while the rates of air pyrolysis are influenced by the crystallite accessibility. A novel IR technique was developed which indicates that levoglucosan formation during combustion is also a function of crystallinity and orientation. A correlation was found between energies of activation and cellulose crystallinities which suggests that the measured values are the sum of separate contributions from the crystalline and less-ordered regions. Cottons, rayon and ramie were given a variety of flame-retardant treatments with reagents

containing either sulfur or phosphorous as the principal flame-retardant component.

NBS-GCR-73-5. **National fire data system, system design project, final report,** 175 pages (Mar. 9, 1973). Order from NTIS as COM 73-10951.

Key words: design criteria; fire hazards; fire losses; fire reporting; fire safety; information systems; National Fire Data System; specifications; state governments; systems analysis.

The design for a multi-file National Fire Data System is described. Data concerned with fire incidents, deaths, injuries, and fire loss will be collected from the fire service, the insurance industry, health service organizations, and a number of special sources. A time-sharing computer center will be utilized through remote terminals to store, manipulate, and aid the reporting of the collected data. Input consists of a series of specified reports from designated data suppliers of a number and type to provide statistically valid coverage for national projection purposes. Each type of input will be stored as a separate system file. The Auerbach report describes the data sources, the proposed processing facility including staffing requirements, probable outputs, and data base specifications; the procedures for data acquisition, encoding, data preparation, data base maintenance, and quality control; and a plan for implementing the system.

NBS-GCR-73-6. **A study of preignition heat transfer through a fabric-skin system subjected to a heat source,** G. Heskestad, A. S. Kalelkar, and H. C. Kung, 53 pages (Dec. 1971). Order from NTIS as COM 73-10959.

Key words: apparel fabrics; fabrics; fire hazards; flammability testing; ignition; skin; thermal burns; thermal measurements.

Theoretical and experimental studies of preignition events transpiring in fabric-skin systems upon exposure to a radiant heat source are reported. Particular emphasis is placed on determining relationships between time to ignition of the fabric and time to pain in the skin of the fabric wearer which allows assessment of probabilities of ignition. Several common fabrics are ranked in order of decreasing safety as the pain time increases relative to the ignition time and evasive action by the fabric wearer becomes less and less effective.

NBS-GCR-73-7. **Study of ignition and exposure,** L. Fourt, 52 pages (Dec. 31, 1971). Order from NTIS as COM 73-10958.

Key words: apparel fabrics; fabrics; fire hazard; flammability testing; ignition; thermal burns.

Simulated sleeves were exposed to a gas range burner, and the time to ignition determined. For cottons and polyester/cellulose blends, the ignition time was proportional to fabric weight, except for napped flannel and terry cloth which ignited rapidly for their weight. Woven and knit fabrics were similar. Nylon and polyester and, in some cases, acetate, shrunk away from the flames unless seams sewn with cotton thread were exposed.

NBS-GCR-73-8. **A study of hazards from burning apparel and the relation of hazards to test methods,** A. Alkidas, R. W. Hess, W. Wulff, and N. Zuber, 208 pages (Dec. 1971). Order from NTIS as COM 73-10954.

Key words: apparel fabric; fabric; fire hazard; flammability testing; thermal measurements; thermodynamic properties.

The following thermal properties of a selected set of cotton, nylon, polyester, acetate, and blend fabrics were measured: thermal conductance, specific heat, ignition or melting temperature, infrared reflectance and transmittance, activation energy, reaction enthalpy, and ignition time under radiative fabric heating. Detailed distributed-parameter ignition models and simplified analyses based on lumped-parameter models were considered, and seven characteristic groups established which govern the heating and reaction processes. Experimental and theoretical results were compared.

NBS-GCR-73-9. **Study of hazards from burning apparel and the relation of hazard to test methods: Flammability of clothing assemblies,** J. F. Krasny and A. L. Fisher, 50 pages (Jan. 19, 1972). Order from NTIS as COM 73-10953.

Key words: apparel fabrics; fabrics; fire hazard; flammability testing; skin; thermal burns; thermal measurements.

The objective of the project was to estimate the area of the body burned and the depth of burn as a function of the garment assemblies worn by clothing fire victims. Such fires were modeled by burning garment assemblies on mannequins covered with temperature indicators; the temperature indicator measurements were correlated with depth of burn into the skin of rats. Chimneys on garments were found to increase very significantly the area of the mannequin raised to elevated temperatures in a given time from ignition; belts tended to act as fire stops. Tighter fit of dresses appeared to cause higher mannequin temperatures, but direct contact of dress and mannequin slowed down fires. Thermoplastic (nylon and polyester) dresses and fire retardant cotton dresses did not ignite in these experiments unless combined with a flammable slip, though the area of potential injury in such combinations was relatively small. Similar areas were raised to elevated temperatures by burning polyester/cotton dresses with or without polyester/cotton slips, but nylon slips seemed to reduce the area.

NBS-GCR-73-10. **Firefighters' breathing system study,** 171 pages (Apr. 1972). Order from NTIS as COM 73-10952.

Key words: breathing apparatus; closed loop breathing apparatus; equipment design; fire fighters; fire fighting; fire fighting equipment; fire gases; open loop breathing apparatus; protective clothing; smoke inhalation; standards.

This report is the result of a study to produce research and development plans for each of three types of firefighters' breathing support equipment. The three design types are the open loop, the semiclosed loop, and the closed loop. The study identified the improvements possible for each design type. This report includes the recommended improvements and lists the time and cost likely for each development.

In addition to the recommendations and development plans for breathing systems improvement, the report includes sections of specifications, breathing gas sources, materials, and other significant elements of the breathing systems. To support the development plans, there are also recommendations for needed laboratory and engineering studies.

NBS-GCR-73-11. **Study of hazards from burning apparel and the relation of hazards to test methods,** O. A. A. Naveda, P. Durbetaki, P. T. Williams, W. Wulff, A. Alkidas, E. R. Champion, W. E. Giddens, R. W. Hess, and B. Kumar, 274 pages (Dec. 31, 1972). Order from NTIS as PB242597.

Key words: apparel, burn injuries; burn injuries, fabric related; burning apparel; fabric related burn injuries.

It was shown that the hazard from fabric-related burn injuries can be quantitatively assessed in terms of the probability that such injury is suffered. This probability depends upon the probabilities associated with the possible events leading to the injury, such as ignition after exposure combustion after ignition and tissue decomposition during and after burning. It was also shown

that the probability of fabric ignition under given exposure depends on the ratio of fabric ignition time to exposure time; hence that the ignition time is an important characteristic required to assess the hazards of fabric-related burn injuries.

NBS-GCR-73-12. **Ease of ignition of fabrics exposed to flaming heat sources,** G. Heskestad, 113 pages (Jan. 1973). Order from NTIS as COM 73-10955.

Key words: apparel fabrics; fabrics; fire hazards; flammability testing; ignition; thermal burns; thermal measurements.

The ease of ignition of fabrics exposed to flames was studied. Ignition or melting times were at a minimum close to the luminous tip of diffusion and to the tip of the inner cone of premixed flames. These minimum ignition times were found to be insensitive to fabric orientation, burner tube diameter, and flame height but varied appreciably for diffusion and premixed flames. With the exception of fabrics with prominent surface structures (e.g., terry cloth), ranking of fabrics by ignition and melting times would be preserved through a large number of exposure modes. A simple theoretical model, which considers the fabric to be impervious and inert, to possess a unique ignition temperature, and to be heated solely by convection, is consistent with the experimental findings. Fabric variables found to be of importance were the fabric weight, average specific heat over the heating interval to ignition and the ignition temperature. Porosity, humidity, proximity to a skin simulant, and weave (except structures like terry cloth) were less important: Flame source variables of importance are the temperature and velocity at the tip, and possibly the diameter of the gas plume at the tip.

NBS-GCR-73-13. **Hazards from burning garments,** G. Arnold, A. Fisher, and G. Frohnsdorff, 85 pages (Mar. 26, 1973). Order from NTIS as COM 73-10957.

Key words: apparel fabrics; fabrics; fire hazard; flammability testing; simulation; skin; thermal burns.

Experiments were carried out to determine the area of the body burned, and the depth of burn likely to be suffered by clothing fire victims as a function of the garment worn, by burning full clothing assemblies on mannequins. It was found that single layer dresses made from nylon, polyester, Nomex, and flame retardant cotton fabrics self-extinguished and could be assumed to cause no injury; single layer dresses of cotton burned somewhat faster than similar weight polyester/cotton blends but the total heat transferred was similar; double layers consisting of dress and slip burned if at least one of the layers was a fabric which would burn in a single layer. The rate of burning and the heat transferred depended on the fabrics used as the dress and the slip; the use of a belt with dresses at least slightly reduced the initial rate of burning and the total heat transferred to the mannequin; all garment combinations which burned transferred sufficient heat to the mannequin to cause second degree and deeper burns, with the greatest burn depth usually on the lower region of the torso.

NBS-GCR-73-14. **Measurement of flammability and burn potential of fabrics, summary report, December 1, 1970-November 30, 1971,** A. K. Mehta and F. Wong, 69 pages (Feb. 15, 1973). Order from NTIS as COM 73-10950.

Key words: apparel fabrics; fire hazard; flammability testing; heat conductivity; simulation; skin.

The objective of this work was to study local skin burn damage due to burning apparel fabrics. Three skin simulants were constructed: two copper-air rod systems simulating the thermal properties of skin with a large depth stretch factor; and one system without depth magnification. Twenty apparel fabrics were burned in the horizontal, 45°, and vertical positions, in the latter two cases with the flame traveling up and down. The injury potential of each fabric was then evaluated.

NBS-GCR-73-15. **Measurement of flammability and burn potential of fabrics,** A. K. Mehta and F. Wong, 331 pages (Feb. 15, 1973). Order from NTIS as PB242582.

Key words: burn, fabric; fabric, burn; flammability.

Two types of inanimate materials having the average thermal properties of human skin were studied. The thermal properties of both types of skin simulants, which were checked by exposing them to known radiant fluxes and monitoring the temperature response, were found to agree closely with the design values.

A set of twenty different fabrics, widely used in apparel, were tested. The depth of thermal damage was found to increase approximately linearly with increase in the total thermal dose to skin, for the exposure times and the magnitudes of the heat fluxes involved in these specific fabric burning experiments. This finding indicates the possibility of rating the burn damage potential of fabrics, crudely, by only two measurements, namely flame spread rate and total thermal damage to skin.

Measurements of the heat transfer rates from the leading edge to the fuel were conducted with the flame spread burner. These experiments indicate that about 2/3 of the preheat energy is delivered ahead of the leading edge of the flame while the highest intensity of energy is confined to a small region under the flame extension.

NBS-GCR-73-16. **Status and prospects for flame resistant polyester/cellulose blend fabrics,** G. C. Tesoro, 56 pages (Mar. 15, 1973). Order from NTIS as COM 73-11265.

Key words: cotton; fabrics; flame retardants; flammability; phosphorus; polyester; rayon; treatments.

This report describes the status of flame retardant finished polyester/cotton and polyester/rayon blend fabrics. While these fabrics represent a large part of the present market, there exists presently no commercial flame retardant treatment for them, though such treatments are available for 100 percent cellulose and 100 percent polyester fabrics. Self-extinguishing behavior can be attained by insolubilizing sufficient phosphorus on the blends, and the amount of phosphorus needed is lowered by the presence of bromine. Phosphorus in the form of phosphine oxide, derived from treatment with tetrakis-hydroxymethyl phosphonium derivatives, has been shown to be more effective than phosphonate or phosphoramine phosphorus. The amount of finish necessary to obtain self-extinguishing behavior, however, tends to stiffen the fabric and raises its cost. Suggestions are made for further research in this area.

NBS-GCR-73-17. **A candidate standard for fundamental BASIC,** J. A. N. Lee, S. R. Bechhardt, and A. I. Karshmer, 148 pages (Oct. 19, 1973). Order from NTIS as COM 74-10932.

Key words: ADP standards; BASIC; compilers; compiler validation; computer programming; formal language; programming language standards.

Under contract to the National Bureau of Standards, a candidate standard specification and supporting analyses have been developed for a nucleus or fundamental subset of the BASIC programming language. This report, in four parts described below, will be immediately considered for Federal standardization, and is intended also to assist national standardization efforts. Part 1: *Standard Specifications for BASIC*. This specification establishes the form and the interpretation of programs

which are written in the BASIC language, for the purpose of promoting a high degree of interchangeability and transportability of such programs among automatic data processing systems. Part 2: *Explanations, Examples and Recommendations.* This part provides explanations, examples, and recommendations which are additional to, but not part of the BASIC specifications. Part 3: *Programs for the Validation of BASIC Implementations.* The BASIC programs contained herein provide a set of routines for the testing and validation of BASIC language implementations. Part 4. *Formal Description of BASIC.* The formal description of BASIC is composed of three parts: the concrete syntax, the abstract syntax, and a semantic description of the operational meanings of the elements of the program.

NBS-GCR-73-18. **Source mechanisms of microearthquakes associated with underground mines in Eastern Utah,** R. B. Smith, P. L. Winkler, J. G. Anderson, and C. H. Scholz, 46 pages (Oct. 1973). Order from NTIS as COM 73-11783.

Key words: acoustics; coal; earthquakes; geologic faults; mining; tectonics.

A detailed microearthquake survey, with acoustic monitoring, was conducted in the Sunnyside coal district of eastern Utah to investigate the possible relationship between earthquakes and mining. Rates of earthquake activity averaged hundreds of events per day with magnitudes from -0.5 to $+2.0$. The zone of greatest earthquake activity was centered 1 km beneath a portion of the mine which exhibited floor and roof failures. A composite fault plane solution for the main zone of activity defines reverse faulting with nodal planes striking N15°E. The P axis has an azimuth of N75°W and dips 25°W. This is in agreement with the general stress pattern attributed to the tectonic development of the nearby San Rafael Swell and suggests that the main earthquake energy may be derived from regional tectonic stress. Acoustic emissions recorded within the mine showed an average rate of 180 per hour and appear to be due to shear failures near the mine walls. The rate of acoustic activity decreased with time after the latest mining activity. Spectral analyses of direct shear waves from the sub-mine quakes yielded estimates of source parameters at hypocentral distances from 1.3 km to 3.0 km. The data are in agreement with the results of other work and extend the previous studies of source spectra down to magnitudes less than $+1$ for short hypocentral distances.

NBS-GCR-73-19. **Regulation and evaluation of industrialized building: A literature review with annotated bibliography,** J. N. Thompson and C. T. Grimm, 60 pages (Dec. 1973). Order from NTIS as COM 74-10481.

Key words: building codes; building laws and regulations; building materials—testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; prefabrication; zoning.

This review, annotated bibliography and index covers literature published in the English language on the regulation and evaluation of industrialized building. The scope of the review includes the period from 1940 to April, 1972.

A summary of the literature precedes the review. The summary follows the subject divisions used in the review.

The review is divided into two parts, titled "Regulation" and "Evaluation." The first part deals with methods used to regulate industrialized housing, including: building codes (local, state, and model); standards; and zoning. The second part deals with the methods used to evaluate industrialized housing, including administration of the evaluation process. Each section of the review presents the literature in chronological order in an attempt to show the development of attitudes, trends, and accomplishments affecting the progress of industrialized housing.

The annotated bibliography is divided into subject sections which correspond to those used in the review. Key words are included for each bibliographic entry. For reference purposes, a comprehensive index includes subjects, authors, and titles cited in the literature review and annotated bibliography.

NBS-GCR-73-21. **Research study on the socioeconomic aspects of low-cost housing in the Philippines,** 149 pages (May 1972). Order from NTIS as COM 74-10722.

Key words: construction; design; developing countries; earthquakes; low-cost housing; natural disasters; Philippines; socioeconomic aspects; typhoons.

The report presents a survey of the historical occurrence of damages by typhoons, selected comparative indices for climate and housing construction, an economic profile of the Philippines, as well as a regional demographic profile. A discussion is also presented on size and density of household dwelling units, trends in housing space expansion, community and municipal facilities; household income and household expenditures; financing sources for housing construction; availability and prices of construction materials and of labor; the capabilities of the housing industries; public reaction to new designs and materials; methods of housing construction and building codes.

NBS-GCR-74-22. **Mechanical and acoustical signature analysis of engine-generator units to be used at the Department of Housing and Urban Development Total Energy Plant, Jersey City, New Jersey,** R. F. Burchill, 374 pages (May 1973). Order from NTIS as COM 74-10934.

Key words: diesel-electric sets; gears; looseness; signature analysis; unbalance; vibration.

This report summarizes the acoustical vibration and stack gas temperature and conditions of each of five diesel-electric sets tested in the vendor's factory. The data in this report was collected simultaneously with fuel, cooling water and electrical transient data during the factory acceptance tests. The tests were supervised by NBS staff and were required by the purchase specifications. The purchase specifications were based upon a total energy performance specification developed by NBS for this project (A Performance Specification For A Total Energy Plant At The Jersey City Breakthrough I Site, NBS Report No. 10313, December 29, 1970). Signature analyses of each engine over the test load range were calculated and plotted. The signature analyses show machinery unbalance rotating component looseness, ball and roller bearing deterioration and gear damage or wear.

These signature analyses are baseline data which will be compared with signature analyses taken at future dates as the engines age. Changes in the signature analysis will be used to predict required maintenance services.

NBS-GCR-74-23. **Survey of lube oil analysis techniques to be used at the Department of Housing and Urban Development Total Energy Plant, Jersey City, New Jersey,** 21 pages (Sept. 1973). Order from NTIS as COM 74-10929.

Key words: chip detectors; ferrograph; lube oil analysis; magnetic drain plugs; oil filters; oil monitors; particle detectors; spectrograph.

Lube oil analysis can be an important consideration in the preventive maintenance program of diesel-engine-generators which provide prime power to a housing site. This report surveyed possible lube oil monitors that would scientifically "in-

form" plant operators when oil needed changing rather than changing the oil after a fixed amount of operating hours.

Several lube oil monitors are discussed. Filter check is used for aircraft gas turbine oil analysis; however, in diesel engines, the presence of combustion products requires a high level of detective skill. Magnetic drain plugs are useful but a failing gear may only show a small amount of ferrous particles while normal wear from cylinder liners, etc. produces large amounts of ferrous particles. Other monitors discussed are: chip detectors, oil particle detectors; spectroscopic oil analysis and ferrograph techniques.

The report recommends that samples of the lube oil be regularly spectroscopically analyzed for wear particles and lubricant degradation. The report also recommends the engine lube oil systems be set-up so that other types of lube oil monitors can be used.

NBS-GCR-74-24. **Development of a test for impact protection,** J. M. Akridge, W. J. Freeston, Jr., W. L. J. Leverett, W. D. McLeod, M. K. Rao, and W. Wullff, 78 pages (Apr. 1973). Order from NTIS as COM 74-10983.

Key words: energy absorption; impact test; protection; protective equipment.

An Impact Test Apparatus has been designed and testing procedures have been proposed to measure systematically on flexible, semi-rigid and rigid impact protection systems their abilities to absorb kinetic energy and to distribute peak impact pressure away from the point of impact.

The proposed impact simulation is based on impact descriptions extracted from the findings of an intensive literature search on impact injuries, primarily car crash impact studies.

An impact modeling analysis was performed and solutions are presented. Modeling parameters and procedures for experimental impact data evaluation have been derived from the analysis.

A multitude of impact modes on practically all parts of the human body, namely skull, torso, leg and arm, have been included in the impact simulation. The proposed versatile Impact Test Apparatus is considered to be a research tool which is needed for the fundamental work that could lead to simple standard test methods for specific impact situations.

NBS-GCR-74-25. **Use type tests for comfort and effectiveness of firemen's turnout coats,** N. R. S. Hollies, L. Fourt, G. A. Arnold, and N. Custer, 129 pages (May 1974). Order from NTIS as COM 74-11075.

Key words: clothing; firemen's turnout coats; use type tests for comfort and effectiveness.

This report describes five tests involving the interaction between a fireman's turnout coat and the fireman working in it. The amount of replication necessary to establish major recognizable differences in present designs is ascertained, together with the standard deviation of typical groups of measurements. The man-hours of subjects and observers required to carry out such comparisons are reported. The tests include the metabolic cost of clothing, rate of mixing of air in spaces inside the coat with outside air, thermal insulation of clothing while being worn, effect of clothing on sweat production and evaporation, and the water uptake by clothing worn under the spray of a fog nozzle.

NBS-GCR-74-26. **Planning computer compatibility for uniform building regulation documents; final report; advanced information systems,** J. Eberhard, T. Tiedeman, and C. Green, 106 pages (May 1973). Order from NTIS as COM 74-11633.

Key words: automatic data processing; building codes; building regulations; computer applications; computers; enforcement; evaluation; information systems; microfilm; microform; state-of-the-art study.

This report provides an introduction to the use of Automated Data Processing (ADP) and microform systems in the administration and enforcement of building regulation, particularly relating to factory manufactured buildings and mobile homes. The focus of the report is to make the reader aware of the planning considerations which must be dealt with when use of these information handling systems is contemplated. A background knowledge of building regulatory functions is assumed of the reader, but not technical knowledge of ADP or microform. Topics covered include: 1. Basic introduction to ADP and microform use. 2. State-of-the-art examples of microform use in building regulation. 3. State-of-the-art examples of computer use in building regulation. 4. Basic planning guidance for ADP and microform use. 5. Potential building regulatory use areas for ADP and microform. 6. Selected references.

NBS-GCR-74-27. **State-local interface relationship in the regulation of manufactured building,** 102 pages (Oct. 1974). Order from NTIS as COM 75-10143.

Key words: building codes; factory-built housing; industrialized building; inspection; manufactured building; model codes; model documents; NCSBCS; on-site construction; prefabricated construction; standards; state-local relationship; state regulations.

A key element in the statewide regulation of manufactured building is the state-local interface relationship. This study sought to isolate existing interface problems and to provide recommended solutions. Problem analysis and solutions presume a regulatory framework drawn along the lines suggested by the proposed Model Manufactured Building Act and Coordinated Evaluation System Documents. Inadequacies in the legislative areas coupled with the lack of a well defined communication system constitute the prime interface problems. Suggestions for legislative changes, including revisions to the Model Act, are presented in this report together with recommendations designed to achieve better communications. Results of the data collection and analysis of existing state legislation are included.

NBS-GCR-74-28. **Study of teletypewriter interface and communications standard. Volume I,** 265 pages (Jan. 16, 1967). Order from NTIS as PB176912.

Key words: alphanumeric symbols; AUTODIN (Automatic Digital Network); JOSS; keyboards; MAC project.

The final report consists of two volumes. The first volume (PB176912) contains the results of the investigations of existing standards, teleprinters, modems, multiplexors, and data processors, and the systems in which they are used. The second volume (PB176913) contains the Formulation and Recommendations of Factors for Standardization.

NBS-GCR-74-29. **Study of teletypewriter interface and communications standard formulation and recommendation of factors for standardization. Volume II,** 69 pages (Jan. 16, 1967). Order from NTIS as PB176913.

Key words: acceptability; coding; costs; data transmission systems; decisionmaking; economics; errors; information theory; input-output devices; interfaces; malfunctions; man-machine systems; remote control systems; systems engineering; state-of-the-art reviews.

The final report consists of two volumes. The first volume (PB176912) contains the results of the investigations of existing

standards, teleprinters, modems, multiplexors, and data processors, and the systems in which they are used. The second volume (PB176913) contains the Formulation and Recommendations of Factors for Standardization.

NBS-GCR-74-30. **Study of teletypewriter interface and communications standards. Task 1. Review of previous standardization programs and existing standards,** P. J. Mellett, 43 pages (Sept. 15, 1966). Order from NTIS as COM 74-11732.

Key words: coding; interfaces; modems; signal processing; standards; teletypewriters.

The report discusses previous and existing standards for the interfaces between data processing equipment and communications systems.

NBS-GCR-74-31. **Study of teletypewriter interface and communications standards. Task 3. Review and comparison of communications terminal equipment of common carriers and other suppliers,** P. J. Mellett, 25 pages (Sept. 30, 1966). Order from NTIS as COM 74-11733.

Key words: common carriers; computer networks; interfaces; modems; telecommunication.

Interface between the communications line and the data processing equipment is provided by line termination equipment. The function of this equipment is to change the digital pulses of the data processor into signals suitable for transmission over telegraph or telephone channels. This type of equipment is usually referred to as a MODEM (modulator-demodulator). Generally, this equipment is available through the common carriers on a lease basis as part of their communication services. There are some commercial suppliers of such terminal equipment, which is generally used in conjunction with private or military communications networks. This task consists of comparing the available communication line terminals that are suitable for coupling teletypewriter equipment and computer multiplex units to communication lines for speeds less than 300 baud. The various units are discussed and are presented on a comparison chart (appended to report), so that corresponding parameters for each equipment may be directly compared.

NBS-GCR-74-32. **Design concepts for safer matches and lighters,** 60 pages (Sept. 29, 1972). Order from NTIS as COM 75-10039.

Key words: burns; fabric fires; fire injuries; flammable fabrics; ignition hazards; ignition sources; lighters; matches.

A match or cigarette lighter is frequently the source of ignition in fires involving the accidental burning of fabric items. Consequently, any design of book matches or lighters which would contribute to their utilization in a safer manner would be highly desirable.

In this report, eight design modifications for book matches and seven modifications for cigarette lighters are described and discussed. The objective of the new designs is to prevent the accidental ignition of clothing or other fabric material when used by children in a play situation or when used for a bona fide application by the adult population. The designs proceeded from a study of ignition sequences gleaned from accident reports filed with the National Bureau of Standards.

Emphasis was placed on developing a safer match design for the protection of the very young, the 0-10 age group. The judgments of the investigators, when applied to a devised rating system, indicated the following: (1) A matchbook designed with a sleeved striker which requires insertion of a thin match and coordinated action of both hands, is the most promising; (2) A lighter concept which utilizes a screened flame is considered the most desirable. Other designs also show a reasonable degree of improvement and it is a conclusion of this report that one or more of the designs described, if adopted, will lead to increased safety for the entire population.

NBS-GCR-75-33. **Impact noise testing and rating,** T. J. Schultz, 245 pages (Dec. 1974). Order from NTIS as COM 75-10133.

Key words: acoustics; building acoustics; impact noise; noise; structural vibration.

This report presents a review of the historical development of and the current state-of-the-art in testing and rating floor/ceiling building construction assemblies with respect to their capability for isolating against annoying impact noises. This review was prepared in order to identify the technological basis underlying the current state-of-the-art and the relevant analytic and experimental methods. Recommendations for future research directed toward the evolution of improved standard test procedures are presented.

NBS-GCR-75-34. **Dynamics of textile fires,** G. H. Markstein and J. deRis, 54 pages (Mar. 1974). Order from NTIS as COM 75-10128.

Key words: edges; fabric construction; fabric flammability; fire spread; flame spread; flame spread rate; surfaces; textiles.

This report is concerned with fire spread rates over the surface and along the edge of textile fabrics and their controlling mechanisms. In a previous study, upward two-dimensional turbulent fire spread was investigated using side-walls to prevent sideways air entrainment. This resulted in a continuously accelerating flame spread over heights of practical interest. In the present study, three dimensional flow was permitted by eliminating the side walls. The resultant flame spread becomes steady soon after ignition. There is evidence for some correlation between the various tests: (1) the small scale 45° upward-burning test (CS 191-53); (2) Miller's measurements on his rotating drum apparatus; (3) our realistic-scale upward tubulent spread; (4) our edge-spread data; and finally (5) the fundamental downward creep spread. The large scale upward spread experiments tend to emphasize the chemical composition differences of fiber materials due to enhanced radiation from the larger flame while the smaller scale tests emphasize fabric construction differences due to the closer similarity of flame and fabric detail length scales.

NBS-GCR-75-35. **Characterization of pavement macrotexture by profile spectral analysis,** J. M. Lawther and J. J. Henry, 93 pages (June 1974). Order from NTIS as COM 75-10341.

Key words: noise; pavement macrotexture; profile tracer; tires.

This report presents the results of a study by the Pennsylvania State University to demonstrate the feasibility of utilizing a profile tracer to measure pavement macrotexture. Four test pavements – part of the Pennsylvania Transportation Institute Skid Test facility – were measured and spectrum analysis plots of the pavement profiles are presented. In addition, space frequency spectrum analyses of the profiles were generated and site-to-site comparisons were made. The results are presented in terms of their potential relationship to tire noise.

NBS-GCR-75-36. **Methodology for hazard evaluation of buildings, Vol. I: Technical report,** J. H. Wiggins, G. C. Hart, T. Hasselman, and R. W. White, 353 pages (Dec. 1973). Order from NTIS as PB261144.

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural disasters and to estimate the amount of expected damage. Damage to both structural and nonstructural building components resulting from the extreme environments produced by earthquakes, hurricanes, and tornados is considered. The methodology is capable of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. The procedure for the methodology is based on a computer analysis of the entire structure and is based on the current state-of-the-art. Numerical examples illustrating applications of the procedure are included.

NBS-GCR-75-37. **Methodology for hazard evaluation of buildings, Vol. II: Computer program users manual,** T. K. Hasselman, R. W. White, and G. Brandow, 112 pages (Dec. 14, 1973). Order from NTIS as PB261145.

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural disasters and to estimate the amount of expected damage. Damage to both structural and nonstructural building components resulting from the extreme environments produced by earthquakes, hurricanes, and tornados is considered. The methodology is capable of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. The procedure for the methodology is based on a computer analysis of the entire structure and is based on the current state-of-the-art. Numerical examples illustrating applications of the procedure are included.

NBS-GCR-75-38. **Methodology for hazard evaluation of buildings, Vol. III: Demonstration report,** J. H. Wiggins, G. C. Hart, and R. W. White, 76 pages (Dec. 1973). Order from NTIS as PB261021.

Key words: buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind.

A methodology is presented for evaluation of existing buildings to determine the risk to life safety from natural disasters and to estimate the amount of expected damage. Damage to both structural and nonstructural building components resulting from the extreme environments produced by earthquakes, hurricanes, and tornados is considered. The methodology is capable of treating a large class of structural types including braced and unbraced steel frames, concrete frames with and without shear walls, bearing wall structures, and long-span roof structures. The procedure for the methodology is based on a computer analysis of the entire structure and is based on the current state-of-the-art. Numerical examples illustrating applications of the procedure are included.

NBS-GCR-75-40. **Polymer flame retardant mechanisms,** D. J. Holve and R. F. Sawyer, 34 pages (Feb. 1975). Order from NTIS as COM 75-10696.

Key words: fire retardant mechanisms; fire retardant polymers; fire retardants; mass transfer number; opposed flow diffusion flame; oxygen index.

An opposed flow diffusion flame technique (Holve and Sawyer, 1974) was used to measure steady state burning rates and extinction velocities for several polymers (with and without added flame retardants) at varying oxygen concentrations in the oxidizing stream. From these results and an analysis based on extinction Damkohler numbers, overall gas phase activation energies and effective mass transfer numbers were derived. Preliminary findings for flame retardant PMMA show that while flame stability is reduced, (i.e., it takes a higher oxygen concentration to sustain combustion) the burning rate increases. In another case for particle board, boric acid flame retardant is found to reduce the burning rate, but not to have any substantial effect on flame stability. These results suggest that both types of retardants are necessary for effective flammability reduction.

NBS-GCR-75-42. **Technological innovation for civilian, social purposes,** E. R. Mottur, 574 pages (July 1971). Order from NTIS as COM 75-10805.

Key words: civilian, technological innovation; social purposes, civilian; technological innovation.

This book presents the results of the Technological Innovation Policy Project which has been carried out in the Program of Policy Studies of George Washington University, under National Bureau of Standards contracts CST-395 and CST-463. The principal sponsors of the research have been the Office of Invention and Innovation, National Bureau of Standards and the U.S. Arms Control and Disarmament Agency. Supplemental research support has been provided by the National Aeronautics and Space Administration, under NASA Institutional Grant NGR 09-010-030 to the Program of Policy Studies in Science and Technology.

NBS-GCR-75-43. **Feasibility study for a diesel engine condition monitoring system for 1179 class LSTs,** M. B. Peterson, 102 pages (Aug. 1975). Order from NTIS as AD-16782.

Key words: diagnostic systems; diesel engines; maintenance costs; monitoring systems.

A study of the maintenance costs and practices on the LST 1179 class ship has been made to determine if a propulsion diagnostic system would result in cost savings to the Navy or other advantages. In the course of this study, a determination of the current propulsion system malfunctions was made and a listing prepared of the necessary sensor measures to detect these malfunctions. Based upon this information, a diagnostic system was proposed and costed. For the LST 1179 ships a simple data system, which measures the trend analysis parameters (plus critical malfunctions), was found to be cost effective.

NBS-GCR-75-44. **Computer/communications networks on a communitywide basis,** E. F. Clark, S. B. Harvey, C. B. Robbins, R. S. Tall, S. S. Tyler, and G. R. Weinberg, 215 pages (June 1975). Order from NTIS as COM 75-10991.

Key words: broadband interactive terminals; cable television uses; checkless society; computer/communications networks; computer/communications services; computer/communications standards; interactive cable television; nonentertainment television; two-way television; wired city; wired nation.

The purpose of this study is to project the possible impact of computer/communications networks on a communitywide basis and to make recommendations for action required by government and/or industry in order to take advantage of such networks and, hopefully, avoid some of the problems inherent in their development. This report reviews, in general, the issues involved with the future development of cable television as one

possible means of "wiring" the community. This report does not attempt to offer detailed solutions to, or discussions of, specific technical, economic, regulatory, legal, or social problems which may be isolated. The report contains a description of two-way cable services, results of a selected opinion survey, the technical and regulatory status of cable television, an outline of network technology, two future contrasting scenarios, a financial model, and conclusions, recommendations, and standards needed. There is a bibliography of 60 sources. The report was prepared under NBS Contract No. 3-36006.

NBS-GCR-75-45. **Pilot investigations into the effect of glare on psychomotor performance,** R. J. Senter, 13 pages (July 1975). Order from NTIS as PB257835.

Key words: glare; lighting; perceptual/motor; psychomotor; safety.

Empirical investigations measured the effects of glare on human psychomotor performance as assessed by a rotary pursuit apparatus. Experiment I demonstrated a minimal performance decrement when glare was reflected off the surface of the pursuit rotor into the subjects' eyes. Following an initial "startle" response, subjects' performance was observed to recover rapidly and at times improve. In Experiment II, then, the glare source was redirected to produce more intense and less diffuse visual interference. Subjects experienced one of two glare levels on three different occasions. A control group was also employed. Again, the major deleterious effect on human performance was a "startle" response produced after intitial exposure to high glare levels. Recommendations were made for future research involving a more complex psychomotor task.

NBS-GCR-75-46. **Methodology for the effective test case selection, Part 1,** W. Howden and L. G. Stucki, 171 pages (Jan. 1974). Order from NTIS as PB247235.

Key words: automatic testing; computer program testing; FORTRAN programs; program analysis; software verification.

The intent of this project was to develop a methodology for partitioning the input domain of a program into equivalence classes. Two sets of input values are to be contained in the same equivalence class if and only if they cause execution of the same path (perhaps to within the number of loop iterations) through a program. The equivalence classes define, therefore, sets of input values which are treated "the same way" by the program. This mapping of input data classes into program execution paths yields a functional description of the program and provides a basis for a systematic approach to test case selection. The investigation began by analyzing the structure of a program and by considering conditions under which certain logical paths are taken. The loop was selected as one of the more complicated structures which had to be investigated. In order to handle loops a boundary-interior methodology was developed. A four phase approach to the general partitioning problem evolved from this methodology. The first phase defines the implicit path description of the partition elements. These descriptions are then simplified in the second phase. The third phase transforms the implicit path descriptions into partially explicit descriptions. The fourth phase consists of predicate solution routines. This boundary interior methodology currently works with simple loops only. Some complex loop structures or improperly nested loops are excluded.

At this point in time, the research efforts documented in this study describe an approach which will achieve the original objective of selecting test data in programs subject to some constraints.

NBS-GCR-75-47. **Methodology for the effective test selection, Phase II, Volumes I and II,** W. Howden and L. G. Stucki, 381 pages (Apr. 1975). Order from NTIS as PB247236.

Key words: automatic testing; computer program testing; FORTRAN programs; program analysis; software verification.

The intent of the Effective Test Case Selection Project is to explore and develop methodologies for partitioning the input space of a program into representative subsets. This ongoing research effort addresses in detail one important aspect of the Automated Verification System Concept being developed at McDonnell Douglas. The problem of providing automated assistance in the selection and construction of meaningful test cases is explored in this study. One key issue of concern involves the identification of a set of criteria for grouping together "similar" program paths. We are faced with the problem of forcing ourselves to find a means of cutting down the number of paths through a program which are significant for testing. Structured programming assists us in the better organization of our programs but yet we still find that exhaustive testing of even structured programs is rarely feasible.

Investigation in the area of automatic selection and construction of test cases has led to the design of a general methodology addressing this problem. The goal of Phase II of this research was to design and implement a prototype system in order to assess its utility and come to a better understanding of the basic program testing problems. The approach taken was general and can be applied to programs in different languages although it was designed with FORTRAN programs in mind.

The prototype system breaks a program down into a finite number of standard sets of program paths. It then attempts to simplify and display the relevant statements and predicates for each class to be tested.

NBS-GCR-75-48. **The avoidance of progressive collapse: Regulatory approaches to the problem,** E. F. P. Burnett, 180 pages (Oct. 1975). Order from NTIS as PB248781.

Key words: abnormal loading; building regulations; design process; European; progressive collapse; regulatory process.

The progressive-collapse related provisions of the building regulations of the United Kingdom, Sweden, Denmark, West Germany, Netherlands, Canada, France, and Eastern Europe are studied in detail. The various regulations are discussed individually for their content, background and interpretation. The report is concluded with a discussion of both building regulatory and design problems associated with the implementation of progressive collapse design requirements. A comparative evaluation is then made of the regulations discussed in the report.

NBS-GCR-75-50. **A theoretical analysis of the ASTM E-119 standard fire test of building construction and materials,** A. M. Kanury and D. J. Holve, 141 pages (Aug. 1975). Order from NTIS as PB247939.

Key words: ASTM Standard E119; building construction; charring; combustion; fire endurance; fire test; flame emissivity; heat transfer; pyrolysis; radiant heat; thermal inertia.

This report describes a theoretical analysis of the ASTM E-119 Standard Fire Test. Both analytical and numerical analyses of the test are performed, indicating how various physical, chemical, and structural variables influence the fire endurance of a construction member. Walls, door, floors and ceilings in heavy timber construction are considered, represented mathematically

as "slabs." Wood, gypsum board, and composite wood-gypsum board "slabs" are discussed. The effects of various fire exposure conditions on the endurance time are assessed. Radiant heat transfer is the dominant heat transfer mode and reradiation properties of the exposed material have a strong influence on the fire endurance time. Thus, the true measure of fire severity is given by the heat flux to the specimen, a function of both the furnace temperature and emissivity.

The exact temporal distribution of temperature exposure has little effect on the fire endurance time as compared to the standard ASTM temperature-time curve. Future improvements of the ASTM E-119 test should focus more on the control, measurement, and specification of the heat flux exposure condition rather than the furnace temperature history.

NBS-GCR-75-51. **Detector sensitivity and siting requirements for dwellings,** R. W. Bukowski, T. E. Waterman, and W. J. Christian, 337 pages (1975). Order from NTIS as PB247483.

Key words: detector sensitivity; detector siting; heat detectors; ionization smoke detectors; photoelectric smoke detectors; residential fires; smoke detectors; tenability levels.

A test program was undertaken to investigate the operation of residential smoke detectors under actual field conditions. The main objectives were to determine: 1) minimum sensitivity, 2) best location and 3) escape time provided by a group of typical detectors. Instrumentation was used to determine theoretical response times of an "ideal" detector as a base line for evaluation of detector performance. The tests were conducted using smouldering or flaming ignition of sofas, chairs and mattresses in various rooms in two abandoned, single-family houses scheduled for demolition. Work was carried out during winter and summer seasons with central heating and cooling on and off.

In addition to a description of the tests and discussion of the results, the report contains all raw data for further analysis by the reader.

The tests indicate both photoelectric and ionization detectors at a sensitivity of approximately 1 percent per foot provide adequate escape time from all the test fires when installed using the following guidelines: 1. The detectors should be installed at the head of each stairway; 2. Outside each separate sleeping area; 3. At least one detector on every level of a multi-level home.

NBS-GCR-76-54. **Characterization of the Stanford Research Institute large-scale heat-release-rate calorimeter,** S. B. Martin, 81 pages (Oct. 1975). Order from NTIS as PB251682.

Key words: calorimeter; combustion; fire test; heat release; limiting thermal index; pyrolysis; radiant heat; thermal sensitivity index.

A scaled up version of the NBS heat release rate calorimeter was constructed at SRI. It can measure specimen sizes up to 18 $\times$ 24 inches over an incident radiant flux range of 1.5 to 7.0 W/cm^2. The performance of the instrument is evaluated and various calibration procedures are described. The effect of specimen size and irradiance is investigated and data is compared with that taken in the NBS instrument. The use of the heat release rate calorimeter as a research tool is discussed. In particular a "limiting thermal index" and a "thermal sensitivity index" are defined.

NBS-GCR-76-55. **Technology for the formulation and expression of specifications. Vol. I: Final report,** J. R. Harris, J. W. Melin, R. L. Tavis, and R. N. Wright, 72 pages (Dec. 1975). Order from NTIS as PB250571.

Key words: building codes; computer model; decision theory; networks; specifications; standards; system engineering.

This report describes a systematic approach to the formulation and expression of specifications that is designed to aid in producing complete, clear, and correct documents. The approach is primarily concerned with the format of specifications, however, it is not possible to entirely separate content and format. It is not expected that the technology will be applied to the formulation of project specifications for construction projects without future study. Three basic tools are used: decision tables for examining the detailed logic contained in each provision, a network for representing the precedence of information in the entire specification, and an outline for organizing all of the provisions in the specification. The report is designed for use by individuals concerned with the preparation of specifications. It does not contain rigorous definitions and proofs of the theorems and algorithms used. Two companion volumes to this report contain a user's manual and a reference manual for the computer software developed as a part of the technology. None of the concepts or algorithms require a computer to be understood or used. Many benefits can be realized by the proper understanding and application of the concepts without using the computer programs.

NBS-GCR-76-56. **Technology for the formulation and expression of specifications. Vol. II: Program user's manual,** J. R. Harris, J. W. Melin, and C. Albarran, 63 pages (Dec. 1975). Order from NTIS as PB250572.

Key words: building codes; computer program; decision theory; networks; specifications; standards; systems engineering.

This report describes the use of three computer programs (DECISION TABLE, NETWORK, and OUTLINE) produced as a part of the study, "Technology for the Formulation and Expression of Specifications." The programs are designed for interactive use from a remote console, and the communication with the programs is in free format, making the programs easy to use for those with limited experience in working computers. The programs are operational on the Burroughs B6700 computer at the Civil Engineering Systems Laboratory (CESL) at the Department of Civil Engineering, University of Illinois, Urbana, Illinois. The principles on which the programs are based and examples of the application of these principles are contained in volume I of this report while a more technical description of the three programs, including logic diagrams, data structure, and program listings, is contained in volume III. This volume contains a description of the use of each program preceded by a chapter describing access to and use of the computer facility at which the programs are operational.

NBS-GCR-76-57. **Technology for the formulation and expression of specifications. Vol. III: Technical reference manual,** R. N. Wright, J. R. Harris, J. W. Melin, and C. Albarran, 118 pages (Dec. 1975). Order from NTIS as PB250573.

Key words: building codes; computer program; decision theory; FORTRAN; logic design; networks; specifications; standards; systems engineering.

This report describes the three computer programs produced as a part of the study, "Technology for the Formulation and Expression of Specifications." The programs are written in FORTRAN IV and are operational on the Burroughs B6700 computer at the Civil Engineering Systems Laboratory (CESL), Department of Civil Engineering, University of Illinois, Urbana, Illinois. Transfer of these programs to other computing facilities will be aided by the contents of the manual, because the pro-

grams are not entirely machine independent. The programs make use of the characteristic word size of the Burroughs equipment (6 characters). Transfer to IBM equipment (which uses 4 characters) will require some reprogramming of the input and output routines. The programs are designed for interactive use from a remote terminal. The input is entered in free format and interpreted by a package of scanning routines at CESL known as PARSE. A manual for PARSE will soon be available from CESL. These programs are envisioned to be prototypes for a more refined computer aid for use with the technology described in volume I of this report.

NBS-GCR-76-58. **Residential sprinkler-protection study,** H. C. Kung, 126 pages (Nov. 1975). Order from NTIS as PB256291.

Key words: automatic sprinklers; bedroom fires; droplet size; heat absorption; pool fires; residential sprinkler protection; sprinkler operation.

A research program was initiated to study sprinkler control of residential fires. Hexane pool fires were selected to simulate source fires. The key parameters of investigation were water-discharge rate and drop size. Results show that as the median drop size decreases at constant discharge rate, an increased reduction is observed in: 1) heat-release rate of the fire, 2) convective heat flux through the room opening, 3) ceiling temperature, 4) gas temperature inside the room, and 5) outflow gas temperature. A correlation has been established between heat-absorption rate and the relative median drop size of the spray. The ratio of the heat-absorption rate to the heat release rate, normalized with the water discharge rate, varies as the minus-0.68 power of the relative median drop size.

A realistic bedroom fire test with flaming ignition was also conducted to evaluate the optimum water discharge rate and sprinkler-orifice diameter determined in the pool-fire tests. The result demonstrated that the suggested optimum sprinkler discharge rate is capable of controlling a realistic bedroom fire.

NBS-GCR-76-59. **Sound power measurements in reverberation chambers,** J. Tichy, M. Brien, and K. Roy, 233 pages (Jan. 1976). Order from NTIS as PB256639.

Key words: measurement technology; reverberation rooms; sound measurement; sound power; sound power levels.

Determination of the sound power emitted by small sources using reverberation rooms is becoming increasingly important as society seeks to implement noise control measures. Many of the critical measurement processes are indicated in American National Standard S1.21-1972, "Methods for the Determination of Sound Power Levels of Small Sources in Reverberation Rooms." This standard, as now embodied, represents a major advance in the state-of-the-art of reverberation room measurement of sound power. It incorporates the best currently available interpretation of measurement technology which is the subject of ongoing research.

NBS-GCR-76-60. **Fire fighter mortality report,** T. Balanoff, 170 pages (Mar. 1976). Order from NTIS as PB253588.

Key words: fatalities; fire fighter; occupational safety and health.

This 15-month study involved the investigation of 101 fire fighters in-the-line of duty deaths. The breakdown of cause of death was: 45 heart attacks, 13 building collapse, 12 burns, 9 smoke inhalations, 6 apparatus accidents, 5 electrocutions, and 1 equipment failure. There tended to be a higher incidence of fatalities occurring in the Mid-Atlantic, East, and New England areas. The mean age of fire fighter's fatality was 43.5 and the mean years of service was 15.8. Sixty percent of the fatalities occurred to men holding the rank of fire fighter. The vast majority of fire fighters who died in the line of duty worked either a split shift (10/14) or a 24-hour shift. There were 14 volunteer fire fighter fatalities.

Summaries of every case are provided in one of three sections: *Fire Fighters Killed While Fighting Fires, Fire Fighters Killed in Non-Fire Situations,* and *Fire Fighters Killed by Heart Attack.*

NBS-GCR-76-61. **Method to determine quality of sapphire,** M. T. Duffy, P. J. Zanzucchi, and G. W. Cullen, 88 pages (Sept. 1975). Order from NTIS as PB253553.

Key words: differential reflection; epitaxial semiconductor devices; Kramers-Kronig relation; multiple reflection; sapphire surfaces; silicon films; specular reflection.

Infrared optical techniques including specular reflection, multiple reflection and differential reflection measurements have been used to evaluate the quality of sapphire surfaces used in epitaxial semiconductor devices. The specular reflection data have been analyzed by use of the Kramers-Kronig relations. These data give a basis for interpreting multiple reflection measurements which are being evaluated for both research and production quality control of sapphire substrates. Correlation of optical reflectance data to x-ray, electrical (e.g., Hall measurements), optical microscopy, and chemical (etch) data is in progress to establish the validity of inferring the extent of lattice damage from reflectance measurements. Application of optical techniques to the characterization of sapphire surfaces, and to semiconductor and dielectric materials in general, is considered. In this context, the optical properties of epitaxial silicon films (on sapphire) have been investigated and, where possible, correlated with the electrical properties of the films as well as with the surface condition of the starting substrates.

NBS-GCR-76-63. **Disk drive interface characteristics,** 105 pages (Apr. 9, 1976). Order from NTIS as PB256440.

Key words: computer disk controllers; computer disk drives; computer disk interface; disk controllers; disk drive characteristics; disk pack interchangeability; disk track format; interface electrical characteristics; interface functional characteristics; removable disk packs.

This report describes and compares the various characteristics of the interface between computer disk drives and disk controllers for those drives using removable disk packs having a storage capacity of approximately 100 million bytes or greater. It presents the findings of an investigation conducted for the National Bureau of Standards in support of the possible development of a Federal Information Processing Standard. Disk pack interchangeability, drive performance characteristics, interface functional characteristics, and interface electrical characteristics are described. The conclusion is reached that although nearly all of the drives reviewed use the same type of disk pack, at the circuit and electrical level substantial differences of a detailed engineering nature exist in the interfaces. Two appendices are given describing (A) details of track format (IBM-compatible) and (B) drive cable attachments and pin numbers. Thirty-three tables and five figures are given. This report was prepared under NBS Contract No. 5-35924.

NBS-GCR-76-64. **Automated integrated circuit processing and assembly,** H. G. Rudenberg, 84 pages (Apr. 1975). Order from NTIS as PB255445.

Key words: automation; electronics; integrated circuits; measurement technology; semiconductor devices; semiconductor process control; silicon.

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This report describes the results of a study on automated procedures for integrated circuit (IC) processing and assembly by the semiconductor industry. Emphasis is on automated IC production, especially processing of wafers and assembly of chips into devices. Major operations that are already or may be automated are identified, and future directions are recommended. Information has been derived primarily from interviews in industry and analysis of automated production equipment. The report discusses the susceptibility of processes to automation: a major requirement for automation is that measurement and control techniques be available to provide consistent results from the processes chosen. The automation status of the key process steps is outlined, and the expected evolution to complete computer control is characterized. Measurement techniques reported are directed towards categories suitable for automation of production in respect to accuracy, range and type. The report cites economic and technical factors likely to inhibit automation in the future, and some factors favoring its adoption. A number of priorities for further action are presented. Differences between the criteria used in automating commercial IC production and automating fabrication of devices for DOD electronic systems are described. Additional information includes references listed in the last section of the report; and summaries of the companies contacted or making equipment analyzed, and of important problems in IC processing or automation perceived by respondents are presented in appendices.

NBS-GCR-76-69. **Methodology for the effective test case selection, Phase III. Final report,** W. Howden and L. G. Stucki, 123 pages (Mar. 1976). Order from NTIS as PB254276.

Key words: automatic testing; computer program testing; FORTRAN programs; program analysis; software correctness; software verification; symbolic program evaluation.

The intent of the Effective Test Case Selection Project is to explore and develop methodologies for improving the tasks of computer program analysis and testing. This research effort explores in detail the problem of providing automated assistance in the selection and construction of meaningful test cases for computer applications programs. Key issues involve the identification of criteria for grouping together "similar" program paths, and a means of reducing the number of paths through a program which needs to be analyzed to ensure correctness. The investigation has led to design of a general methodology addressing this problem. Phase III of this research has resulted in the completion of a prototype software testing tool called DISSECT. The DISSECT system addresses the general methodology as well as the design and implementation of additional features whose importance was indicated by experiments with an initial Phase II system. DISSECT provides capabilities to analyze FORTRAN program paths and to symbolically evaluate the potential execution results. Commands are available to select program paths based upon branches and number of loop iterations, and to select DISSECT outputs such as path descriptions or the set of input predicates that cause paths to be followed. DISSECT is an experimental program, written in LISP for a Digital Equipment Corporation PDP-10 computer.

NBS-GCR-76-70. **An investigation of test methods for determining the flammability hazards of fabrics,** K. N. Yeh, I. Block, B. F. Smith, and S. Spivak, 67 pages (June 21, 1976). Order from NTIS as PB254748.

Key words: fabric flammability; fabrics; ignition; heat energy; tests.

The measurement of char length and burn time of a variety of sample specimens was conducted to determine the effects of varying sample size, sample shape, ignition source and air flow past the sample, on these two parameters.

In addition, samples tested in the DOC FF3-71 cabinet were subjected to conditioning at various relative humidities prior to evaluation.

The results of this work indicate that flammability test methods should conform to the following guidelines: (1) the suspension method should be such as to exert as little force in the plane of the fabric as possible, (2) the test specimen should be wide enough to permit unlimited burning in all directions, (3) the ignition source should be capable of providing a precise energy input at a constant rate to the fabric, (4) a forced air flow through the cabinet may be required, (5) although preconditioning humidity may not greatly affect the results when testing nonhydrophilic thermoplastics, moisture sorption can be important, and (6) seamed samples are unnecessary except where the added thread is a significant portion of the weight of the fabric under test.

NBS-GCR-76-71. **Extinguishment in apparel textiles,** G. Tesoro and S. Backer, 60 pages (Oct. 1975). Order from NTIS as PB254751.

Key words: cotton; cotton/polyester; extinguishment; fabric flammability; fabrics; fibers; finishes; flame retardant treatments; nylon; wool.

An experimental investigation of the extinguishability during combustion of various apparel fabrics was conducted. Cotton, wool, nylon, cotton/polyester and FR cotton/polyester were ranked according to burning behavior under test conditions of DOC-FF-3-71 with the addition of heat sinks near the fabric. Stationary and movable heat sinks of various thermophysical properties, geometries, dimensions and speeds were considered.

It was found that extinguishability is affected by fiber type and finish, by weight per unit area and structure. Two parameters were identified to measure relative extinguishability: (1) minimum constant spacing (between fabric and heat sink) needed to induce extinguishment, and (2) the maximum char length obtained after extinguishment in the case of a variable fabric to heat sink spacing. It is concluded that relative differences in ease of extinguishment of nonthermoplastic fabrics can be quantitatively and reproducibly measured.

NBS-GCR-76-72. **Evaluation of fire protection spray devices: The state-of-the-art,** W. G. Labes, 102 pages (June 30, 1976). Order from NTIS as PB256190.

Key words: automatic sprinklers; bibliography; droplet size; fire suppression; spray nozzles; spray patterns; test methods; water distribution; water spray.

This report represents a descriptive review of the state-of-the-art on spray nozzle characteristics, drop-size measurement, and drop-size distribution and spray pattern analysis. A discussion of significant information gaps is also included. A list of references supporting these findings has been prepared and appears as an appendix to this report.

It is concluded that the evaluation of fire protection spray devices must be updated to include considerably more than the volume distribution of water at some standardized distance below the deflector of a sprinkler. Since both the fire environment and the spray structure are three dimensional by nature, and, as these opposing forces occur simultaneously in real fire situations, it is desirable to understand in greater detail the application of water to fire by fire protection spray devices.

NBS-GCR-76-73. **Mapping of recurrent behavior patterns in institutional building under fire: Ten case studies of nursing facilities,** L. Lerup, D. Greenwood, and J. S. Burke, 165 pages (July 1976). Order from NTIS as PB257424.

Key words: building fires; case studies; critical events; decisions; episodes; fires; home for the aged; hospital fires; human behavior; institutions; mapping; models; nursing homes; realms.

Report provides a graphical and narrative mapping of the fire and people behavior patterns in 10 institutional buildings under fire conditions. The case studies concentrate on nursing home type facilities. The report maps out the progress of the fire by realms of fire development and critical events separating these realms. A parallel mapping is included for human behavior covering the episodes and decisions involved. A conceptual framework and analysis of the basic concepts and approaches are included.

NBS-GCR-76-74. **Low-rise low-cost housing and extreme wind related problems in Bangladesh,** J. R. Choudhury, 39 pages (Apr. 1975). Order from NTIS as PB256771.

Key words: Bangladesh; housing; low-cost housing; low-rise buildings; wind.

This report furnishes information on socioeconomic factors, the present conditions of urban and rural housing, and housing needs in Bangladesh for the next 10 years. It also provides data on available wind speed records and wind damage statistics and discusses some special problems unique to Bangladesh.

NBS-GCR-76-75. **Accident research methodologies,** N. W. Heimstra, 27 pages (Dec. 10, 1976). Order from NTIS as PB261201.

Key words: accident research; countermeasures; epidimiology; laboratory research; methodology; naturalistic studies; safety.

This overview paper discusses some of the problems encountered and methodologies used in accident research. Several methodologies are briefly presented—the epidimiological approach, laboratory studies, case studies, and naturalistic observations. Special problems in childhood accident research and in countermeasures are emphasized and a model of human accident behavior is presented. Selected references are included.

NBS-GCR-76-76. **Home accidents and safety,** M. Werber, 100 pages (Dec. 10, 1976). Order from NTIS as PB261200.

Key words: accidents; accident research; consumer accidents; epidimiology hazards; home safety; methodology; safety.

This report briefly summarizes published research in home accidents and safety. Areas covered are: theoretical approaches to safety, behavorial interpretations, research design, hazardous products and conditions, childhood and old age accidents, epidimiology and public health, and accident prevention. In addition to the reference and general bibliographies, an author index, a subject index and permuted title index are included.

NBS-GCR-76-79. **A problem in fire safety: Flame spreading across liquid fuels,** F. L. Dryer, I. Glassman, and W. A. Sirignano, 30 pages (Sept. 15, 1976). Order from NTIS as PB259127.

Key words: combustion models; flame spread; fluid flow; laser doppler velocimetry; liquid fuels; solid fuels; surface tension.

This report provides a brief summary of experimental and theoretical work carried out at Princeton University on flame spreading across liquid fuels. The importance of surface tension driven flows ahead of the flame front in controlling flame spread across liquids at temperatures below the flash point was demonstrated experimentally. Buoyancy and radiation effects were also present but were of lesser importance. Variations in the temperature of the liquid surface are attributed to eddies in the gas phase ahead of the flame front. These eddies may also play a role in flame propagation across solid combustibles. It is proposed to investigate these eddies by means of laser doppler velocimetry. A two-dimensional, steady-state computer program is under development for use as a tool in studying flame propagation above liquid and solid fuels.

NBS-GCR-ETIP 73-01. **Study of strategies for market aggregation,** J. D. Lewis and H. S. Kleiman, 253 pages (May 11, 1973). Order from NTIS as COM 73-11373.

Key words: aggregation, market; market aggregation; tool, market.

This report considers the opportunities for stimulating the development and application of technology in the civilian sector through the use of the tool of market aggregation. Market aggregation is defined as a restructuring of demand to reduce variability in the marketplace. Such reduced variability might be manifest in an increased concentration of the purchasing activities of different buyers or in new standards for products or for their use. In addition to discussions of background and methodology, the report develops a conceptual framework for market aggregation that provides a specific aggregation strategy to treat a given problem. Next four case studies are presented to provide insights for the conceptual framework. These are followed by a discussion of major factors to be considered when contemplating or using market aggregation. The report concludes with suggestions on possible experiments with the market aggregation tool. One appendix to the report discusses antitrust considerations in market aggregation and another provides full details on the four case studies.

NBS-GCR-ETIP 73-02. **Government procurement as an incentive to commercial technology and innovation,** 159 pages (Mar. 1973). Order from NTIS as COM 73-11375.

Key words: ETIP; government procurement; performance specifications; procurement mechanisms; technology incentives.

The Federal Government influences the development and application of technology through its procurement of R&D to meet federal needs, its purchase of goods and services for federal use, and its subsidization of purchases made by other bodies. By altering certain aspects of its procurement practices and procedures, which are described and discussed in this study, the government may further stimulate private investment in technological innovation. Some suggested procurement approaches can be implemented within the confines of existing legislation and without major regulatory change. These include incentives (patent and financial) to commercialize the results of government R&D, the increased use of performance specifications in the procurement of commercial goods and services, and a government-wide policy to procure innovative goods and services that impact favorably on particular national needs. The procurement approaches can be tested by experiments of the one-time "demonstration" type or of the more practical "piggyback" type, in which a planned or ongoing procurement is modified so as to stimulate innovation. Several examples of experiments that meet appropriate criteria are given in the report,

and recommendations for selecting, designing, performing, and evaluating additional experiments are presented.

NBS-GCR-ETIP 73-03. **Technology transfer and technological innovation: Annotated and selected bibliographies,** 107 pages (July 10, 1973). Order from NTIS as COM 73-11374.

Key words: bibliography, technological innovation; innovation, technological; technological innovation.

The works included in the bibliographies have been categorized according to their relevance to federal and nonfederal activities as well as to the general quality and significance of their discussions on technology transfer or technological innovation. The annotated bibliography includes 315 entries relevant to federal government action and all are of high quality. Approximately 50 additional entries for work of high quality with relevance to nonfederal action are also included. The selected bibliography contains approximately 375 entries, categorized in the same manner.

NBS-GCR-ETIP 73-04. **Experimental technology incentives program procurement experiment plan 1: Stimulating noise control technology in consumer products through federal government procurement action,** 18 pages (Oct. 1973). Order from NTIS as COM 74-10256.

Key words: ETIP; government procurement policy; noise reduction; performance specification; technology incentives.

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards (NBS) is part of the continuing effort to understand how the federal government can work more effectively with industrial partners from the private sector in the application of science and technology in the nations interest. ETIP has selected the Federal government procurement policy as one of the specific areas in which to focus its investigations. This experimental plan details the particulars of one of a series of experiments to be conducted by ETIP in association with the Federal Supply Services of the General Services Administration. The specific objective of this experiment is to seek the introduction of improved noise control technology into power lawn mowers that are used by both the government and consumers generally. A 2-step fixed-price negotiated procurement experiment will be conducted utilizing a new performance specification relative to noise emission of the lawn mowers.

NBS-GCR-ETIP 73-05. **Experimental technology incentives program procurement experiment plan 2: Stimulating efficiency and noise abatement in room air conditioners through federal government procurement action,** 51 pages (Nov. 1973). Order from NTIS as COM 74-10257.

Key words: energy conservation; ETIP; government procurement policy; noise reduction; performance specification; technology incentives.

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards (NBS) is part of the continuing effort to understand how the federal government can work more effectively with science and technology in the nations interest. ETIP has selected the federal government procurement policy as one of the specific areas in which to focus its investigations. This experimental plan details the particulars of one of a series of experiments to be conducted by ETIP in association with the Federal Supply Services of the General Services Administration. The specific objective of this experiment is to seek the introduction of improved noise control technology and improved energy technology into room air conditioners that are used by the government and by consumers. The procurement approach to be tested will be the approach of performance factors in evaluation of bids responding to a formally advertised procurement.

NBS-GCR-ETIP 73-06. **Experimental technology incentives program procurement experiment plan 3: Stimulating increased efficiency in frostless household refrigerators through federal government procurement action,** 45 pages (Nov. 1973). Order from NTIS as COM 74-10258.

Key words: energy conservation; ETIP; government procurement policy; technology incentives.

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards (NBS) is part of the continuing effort to understand how the federal government can work more effectively with industrial partners from the private sector in the application of science and technology in the nations interest. ETIP has selected the federal government procurement policy as one of the specific areas in which to focus its investigations. This experimental plan details the particulars of one of a series of experiments to be conducted by ETIP in association with the Federal Supply Service of the General Services Administration. The specific objective of this experiment is to see improved energy technology in production of frostless household refrigerators to be used by government and by consumers. The procurement approach to be tested will be the use of life cycle cost comparison bid evaluation in a formally advertised procurement.

NBS-GCR-ETIP 73-07, Vol. 1. **Development of criteria and an operating procedure for screening government owned patents,** P. G. Dickey, K. D. Brown, R. W. Aaron, and S. A. Lambert, 82 pages (Apr. 30, 1973). Order from NTIS as COM 74-10939.

Key words: ETIP; government-owned patents; patent screening; technology incentives.

This two volume report describes the development of procedures to screen government-owned patents for commercial potential, based on the patent screening practices of a selected sample of industrial firms; results of the research show that the operating procedure developed satisfies the basic requirements of the study. Technology Generalists were about to apply the developed procedure with a minimum of assistance from Technology Specialists. The procedure, however, cannot readily be applied by nonexperts. Test results of screening selected patents were consistent and in accordance with expected results. The conclusion is drawn that the results indicate that the developed operating procedure replicates the approaches both formal and intuitive commonly used by industrial executives and experts to screen patents. The benefits and usefulness of operating procedures are summarized as follows: 1. Systematization of a screening process which heretofore was essentially random; 2. Uniform application of eight criteria consistently regarded as most important by industrial executives in patent screening; 3. A means for prioritizing patents in terms of some quantitative measurement of commercial potential; 4. A means of screening large numbers of patents in an efficient manner; 5. Procedure can be utilized by generalists as well as specialists.

NBS-GCR-ETIP 73-07, Vol. 2. **Development of criteria and an operating procedure for screening government owned patents,** P. G. Dickey, K. D. Brown, R. W. Aaron, and S. A. Lambert, 316 pages (Apr. 30, 1973). Order from NTIS as COM 74-10940.

Key words: ETIP; government-owned patents; patent screening; technology incentives.

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potential, based on the patent screening practices of a selected sample of industrial firms; results of the research show that the operating procedure developed satisfies the basic requirements of the study. Technology Generalists were about to apply the developed procedure with a minimum of assistance from Technology Specialists. The procedure, however, cannot readily be applied by nonexperts. Test results of screening selected patents were consistent and in accordance with expected results. The conclusion is drawn that the results indicate that the developed operating procedure replicates the approaches both formal and intuitive commonly used by industrial executives and experts to screen patents. The benefits and usefulness of operating procedures are summarized as follows: 1. Systematization of a screening process which heretofore was essentially random; 2. Uniform application of eight criteria consistently regarded as most important by industrial executives in patent screening; 3. A means for prioritizing patents in terms of some quantitative measurement of commercial potential; 4. A means of screening large numbers of patents in an efficient manner; 5. Procedure can be utilized by generalists as well as specialists.

NBS-GCR-ETIP 75-01. **Fiber, textile and apparel research—Cotton polyester blends, July 1974-75,** 143 pages (Aug. 1975). Order from NTIS as COM 75-11369.

Key words: cotton polyester blends; ETIP; flame retardants; flammability; R&D contracting; radiation grafting; research consortia.

As a part of its experimental program with respect to the funding of civilian research and development by the Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract where the basis for award was rather unique. The two major criteria for the award were: (1) the identification of specific research to be pursued in a general problem area and (2) the efforts at commercialization that the contractor indicated he would pursue. The contract was awarded to a consortium headed by Clemson University. This report covers the technical progress made during the first year of the research activity.

Based on this research, it is now possible to predict with a high degree of certainty, the types of chemical agents which should be effective in rendering cotton and polyester fabrics flame retardant. The interaction which occurs between fiber systems in a blend have been elucidated. Further, it has been possible to determine the effect of various distributions of the flame retardant chemicals among fibers in several systems. Four specific approaches are now under investigation.

NBS-GCR-ETIP 76-03. **Federal funding of civilian research and development, Vol. 1. Summary,** 62 pages (Feb. 1976). Order from NTIS as PB251266.

Key words: decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to Arthur D. Little, Inc. to conduct a study whose purpose was "To better understand how federal funding of civilian research and development has functioned as an agent of technological change in the private sector."

The fundamental conclusion reached in the study was "Federally-funded civilian research and development is not sufficient to bring about technological change in the private sector to any significant extent." This is true because R&D cost is a small part of the total cost of bringing technological innovation into the marketplace. The study finds that this fact is often overlooked by federal policy makers in both the Executive and Legislative Branches. It is cited as one of the reasons why many United States companies with proven records of developing and marketing new products often shun federal R&D funds, and why so many federal R&D projects are shelved.

The authors suggest that the results of the study indicate that federal funding of civilian R&D should be formulated in the larger context of the complex process of technological innovation. This volume provides a summary of the study.

NBS-GCR-ETIP 76-04. **Federal funding of civilian research and development, Vol. 2. Case studies,** 335 pages (Feb. 1976). Order from NTIS as PB251683.

Key words: decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to Arthur D. Little, Inc. to conduct a study whose purpose was "To better understand how federal funding of civilian research and development has functioned as an agent of technological change in the private sector."

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The authors suggest that the results of the study indicate that federal funding of civilian R&D should be formulated in the larger context of the complex process of technological innovation. This volume provides details of the case studies upon which the findings were based.

NBS-GCR-ETIP 76-05. **Analysis of federally funded demonstration projects, Vol. 1. Executive summary,** W. S. Baer, L. L. Johnson, and E. W. Merrow, 32 pages (1976). Order from NTIS as PB253108.

Key words: demonstration projects; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to RAND, Santa Monica, CA, to conduct a study whose purpose was "To develop cost benefit and market/industrial/institutional criteria and guidelines for the use of Federally procured demonstration projects as catalysts for technological change."

The analysis indicated that projects successful in diffusion tend to have the following attributes: (1) A technology well in hand, (2) Cost and risk sharing with local participants, (3) Project initiative from non-Federal sources, (4) The existence of a strong industrial system for commercialization, (5) Inclusion of all ele-

ments needed for commercialization, and (6) Absence of tight time constraints.

The study developed guidelines for demonstration projects. These are grouped under the headings of (1) Strategies for Demonstrations, (2) Initial Exploratory Study, (3) Project Planning and Implementation, (4) Management, Monitoring, and Evaluation, and (5) Dissemination of Results. This volume provides an Executive Summary of the research.

NBS-GCR-ETIP 76-06. **Analysis of federally funded demonstration projects, Vol. 2. Final report,** W. S. Baer, L. L. Johnson, and E. W. Merrow, 197 pages (1976). Order from NTIS as PB253918.

Key words: demonstration projects; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology.

As a part of its program with respect to the funding of civilian research and development by the Federal Government, the Experimental Technology Incentives Program of the National Bureau of Standards awarded a contract to RAND, Santa Monica, CA, to conduct a study whose purpose was "To develop cost benefit and market/industrial/institutional criteria and guidelines for the use of Federally procured demonstration projects as catalysts for technological change."

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NBS-GCR-ETIP 76-08. **An analysis of venture capital market imperfections executive summary,** 46 pages (Feb. 1976). Order from NTIS as PB254078.

Key words: capital market imperfections; federal technology policy; SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital.

The study estimated the total flow of funds to small technology based firms, and the composition of that flow according to financial instruments. The relative roles of various suppliers of funds to these firms were assessed. No evidence was found of substantial market imperfections that restrict the flow of funds to small technology based firms. There was no indication that small technology based firms paid higher rates of interest or returned their unaffiliated stockholders more than other small firms. There was no indication that suppliers of funds to small technology based firms earned higher profits than could be earned by investing in listed securities. No elements of the structure of behavior in the venture capital industry were found which would enable firms in the business to charge higher rates or earn greater profits than necessary to compensate for the risks assumed.

The conclusion that there are no substantial capital market imperfections does not necessarily imply that the supply of funds to new technology based firms is in some sense ideal. Investment in small technology based firms may generate external effects so that the benefits to society from investment in these firms may not be accurately reflected in the prices those firms can get for their products and services or the rate of return which investors in such firms can expect to earn.

NBS-GCR-ETIP 76-09. **Life cycle costing in the procurement of electric ranges,** 27 pages (1976). Order from NTIS as PB253488.

Key words: electric ranges; energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments.

This report documents life cycle cost procurements of electric ranges made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why electric ranges were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-10. **Life cycle costing in the procurement of refrigerator-freezers,** 40 pages (1976). Order from NTIS as PB253260.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; refrigerators.

This report documents life cycle cost procurements of refrigerators made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why refrigerators were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-11. **An evaluation of the Small Business Administration Innovation Loan Program,** 119 pages (1976). Order from NTIS as PB253115.

Key words: Experimental Technology Incentives Program; federal policies; innovation loans; R&D; small business; Small Business Administration; technological change.

This is an evaluation of the Innovation Loan Program (ILP), developed and administered by the Small Business Administration during 1966-70 to assist small businesses to market innovations they had developed. The agency's objective was to support new products or processes which could be expected to achieve significant societal benefits.

Approximately 90 loans totaling more than $7 million were made during the life of the program. This evaluation was limited to the 37 identifiable loans.

Borrower entities were analyzed to determine patterns of success and failure, and the merits of their innovations. Technological sophistication and social utility of the innovations were as-

sessed. Employment and tax effects of the program were measured. Borrowers were found to be typically small, newly established, undercapitalized firms with a single product. The program was adjudged a qualified success, and revival of this or a similar program is recommended.

NBS-GCR-ETIP 76-12. **An analysis of venture capital market imperfections,** 438 pages (Feb. 1976). Order from NTIS as PB254996.

Key words: capital market imperfections; federal technology policy; SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital.

The study estimated the total flow of funds to small technology based firms, and the composition of that flow according to financial instruments. The relative roles of various suppliers of funds to these firms were assessed. No evidence was found of substantial market imperfections that restrict the flow of funds to small technology based firms. There was no indication that small technology based firms paid higher rates of interest or return their unaffiliated stockholders more than other small firms. There was no indication that suppliers of funds to small technology based firms earned higher profits than could be earned by investing in listed securities. No elements of the structure of behavior in the venture capital industry were found which would enable firms in the business to charge higher rates or earn greater profits than necessary to compensate for the risks assumed.

The conclusion that there are no substantial capital market imperfections does not necessarily imply that the supply of funds to new technology based firms is in some sense ideal. Investment in small technology based firms may generate external effects so that the benefits to society from investment in these firms may not be accurately reflected in the prices those firms can get for their products and services or the rate of return which investors in such firms can expect to earn.

NBS-GCR-ETIP 76-13. **Life cycle costing, procurement case 1, room air conditioners,** 28 pages (July 1975). Order from NTIS as PB253475.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; room air conditioners.

This report documents life cycle cost procurements of room air conditioners made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why room air conditioners were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-14. **Life cycle costing, procurement case 2, water heaters,** 24 pages (July 1975). Order from NTIS as PB253476.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; water heaters.

This report documents life cycle cost procurements of water heaters made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why room air conditioners were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-15. **Life cycle costing, procurement case 3, gas ranges,** 30 pages (Jan. 1976). Order from NTIS as PB253477.

Key words: energy efficient products; Experimental Technology Incentives Program; gas ranges; life cycle costing; procurement experiments.

This report documents life cycle cost procurements of gas ranges made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why room air conditioners were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-16. **An experiment on accelerating the writing of nuclear standards conducted for the American National Standards Institute,** N. G. Wittenbrock, 237 pages (Sept. 1975). Order from NTIS as PB256129.

Key words: administrative experiment; American National Standards Institute; Experimental Technology Incentives Program; Nuclear Regulatory Commission; standards development; technological change.

This project was an *administrative experiment,* run in cooperation with the NRC and the American National Standards Institute. Its purpose was to determine whether any or all of four changes in the method of developing nuclear standards is a desirable method for accelerating the establishment of responsible standards which are approved by ANSI and adopted by the Nuclear Regulatory Commission. Several changes in the normal way consensus standards are drafted were made to see if their development could be expedited and the information underlying them increased. It tested: (1) the use of a full-time committee chairman (versus a volunteer chairman), (2) the provision of technical editorial services for the preparation of early draft standards, (3) the provision of technical secretarial help to expedite the translation of committee discussion into draft standards, and (4) the convocation of committees for an extended period of time by paying out of pocket costs. It was hypothesized that the changes would substantially reduce the amount of time consumed by coordinating views via the mail, telephone, and through shorter meeting periods.

NBS-GCR-ETIP 76-17. **A guide for applying the concepts of life cycle costing to procurements by state and local governments,** 209 pages (1976). Order from NTIS as PB254233.

Key words: bid evaluation; Experimental Technology Incentives Program (ETIP); innovation; life cycle costing; local government; procurement policy; state government.

This guide has been developed to assist the public purchasing community to more fully understand, and use the elements of life cycle costing in the procurement process.

The guide contains chapters on concept and theory of LCC, use of LCC in equipment purchases, use of warrantees in LCC structuring LCC procurements and selected case studies plus appropriate contract clauses in equipment procurement.

The guide has application at the Federal, State and local levels of procurement activity and for industrial purchasing agents as well.

The guide was developed as part of the Experimental Technology Incentives Program's research in the use of procurement policies in providing incentives to innovation and technological change.

NBS-GCR-ETIP 76-18. **Value incentive program household goods shipping containers,** 40 pages (July 1976). Order from NTIS as PB256642.

Key words: Experimental Technology Incentives Program (ETIP); Federal Supply Service; life cycle costing; procurement policy; specifications; value.

This case study covers the use of the Value Incentive Clause by a GSA/FSS contractor to make product improvement suggestions on Household Shipping Containers. The use of this clause allows for contractors who hold FSS contracts to make suggestions to reduce the overall cost of procurement to the government and to share in the savings resulting from their suggestion. Copies of the GSA order, and the clause itself are included in addition to the specific changes proposed for the household containers. As the result of this suggestion the government will save about $7.5 million dollars over 10 years. The contractor's share of the first year's savings exceeds $150,000.

NBS-GCR-ETIP 76-19. **Life cycle costing in the procurement of window air conditioners,** 38 pages (July 1976). Order from NTIS as PB256643.

Key words: energy efficient products; Experimental Technology Incentives Program; life cycle costing; procurement experiments; window air conditioners.

This report documents life cycle cost procurements of window air conditioners made by the Federal Supply Service (FSS), General Services Administration (GSA). These procurements were part of a program instituted by FSS to apply life cycle costing techniques to its procurement process. This program was instituted in conjunction with the Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards. The material contained in the report explains why refrigerators were selected for LCC, how the LCC criteria were developed, and what results were obtained. Details concerning the screening process used in selecting the products, the preparation of the invitation for bid document, the bids received, and the evaluation, analysis and award process are covered in the report.

NBS-GCR-ETIP 76-22. **Development of flame retardants for polyester/cotton blends,** R. H. Barker and M. J. Drews, 472 pages (Sept. 1976). Order from NTIS as PB257884.

Key words: antimony oxide; bromine; bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; fabric flammability; flame retardant mechanisms; flame retardant monomers; flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; phosphorus flame retardants; polyester; precondensates; radiation grafting.

Initial studies were carried out to determine the flame retardant characteristics of the individual polyester and cotton fibers. Since previous studies had dealt primarily with cotton and other cellulosic materials, emphasis was placed on the polyester. Structural and chemical factors affecting flammability were determined and evaluated. The interaction of the fibers was studied in both the presence and absence of flame retardants. Several specific types of phosphorus and bromine-containing materials were evaluated to determine their relative retardant efficiencies. Various methods of fixing flame retardants onto polyester were also studied with particular emphasis placed on radiation grafting techniques. Based on the results of these studies several series of model flame retardant treatments were prepared and evaluated on 50/50 blend fabrics. The results of these studies were then used as the basis for designing new flame retardant systems having a potential for commercial application. These systems include phosphonium oligomers, a bromine-containing phosphazene and brominated aromatics with a brominated acrylate binder.

NBS-GCR-ETIP 76-23. **Value incentive program computer room air conditioning units,** 35 pages (July 1976). Order from NTIS as PB258991.

Key words: computer air conditioning units; Experimental Technology Incentives Program (ETIP); Federal Supply Service; life cycle costing; procurement policy; specifications; value incentives.

This case study covers the use of the Value Incentive Clause by a GSA/FSS contractor to make product improvement suggestions on Computer Room Air Conditioning Units. The use of this clause allows for contractors who hold FSS contracts to make suggestions to reduce the overall cost of procurement to the government and to share in the savings resulting from their suggestion. Copies of the GSA order, and the clause itself are included in addition to the specific changes proposed for the computer room air conditioning units. As the result of this suggestion the government will save about $394,000 dollars over 10 years. The contractor's share of the first year's savings exceeds $7,000.

NBS-GCR-ETIP 76-24. **A framework for analyzing commodity supply restrictions,** 240 pages (1976). Order from NTIS as PB258093.

Key words: applied microeconomic framework; commodity supply crisis; econometric analysis; economic impacts; efficiency impacts; income distribution effects; policy alternatives.

Study addresses commodity supply crises due to producer country export policies, and considers the issue of resource exhaustion only as it relates to this problem. The primary concern is with *economic* impacts and policies. Crises in commodity supplies may well have political impacts, but detailed treatment of such effects is beyond the scope of the study. Possible political and diplomatic constraints on U.S. policies are considered, but the primary concern is with economic impacts.

Policies differ in their effects on the distribution of income between producers and consumers. Such effects are considered, where appropriate. Concentration is on efficiency impacts, however, and there is no attempt to address effects on the size distribution of income.

The basic analytical approach is that of the applied microeconomist working in a supply and demand framework. This framework allows the use of available qualitative economic, econometric and engineering information. There has been no use of mathematical programming or input-output techniques as it is

believed that the techniques employed are, for the purposes of this study, more productive within time and budget constraints.

U.S. Patent 3,950,995. **Ambient pressure probe,** R. D. Marshall, (Apr. 20, 1976).

Key words: ambient pressure probe; omnidirectional pressure probe; pressure probe shroud; static pressure; weatherproof pressure probe; wind field pressure measurements.

Ambient or static pressure in a fluid stream is sensed with a hollow circular cylinder placed normal to the fluid stream. A shroud is mounted on the cylinder for adjustment over a ring of ports provided in the cylinder. In this manner, the relationship between the internal pressure in the cylinder and the ambient pressure is controllable. Ideally, the internal and ambient pressures are exactly equal. Further, extension of the cylinder above and below the shroud provides symmetry for positive and negative angles of attack.

U.S. Patent 3,958,269. **Color subcarrier frequency comparator,** D. D. Davis, (May 18, 1976).

Key words: color subcarrier; frequency calibration; frequency comparator; frequency measurements; oscillator calibration; phase comparison; television receiver.

Apparatus for measuring the frequency of a reference signal which utilizes the color subcarrier signal of a television receiver as a standard frequency signal. In a first embodiment, the reference signal controls a circuit to develop bursts of a synthesized color subcarrier signal, gated at the horizontal line rate of a color television receiver. The synthesized signal is superimposed on the broadcast television signal and applied to the receiver to produce a modulation bar on the screen. Any frequency/phase difference between synthesized and broadcast color subcarrier signals will cause the modulation bar to move laterally across the screen, and/or cause the sequence of colors within the modulation bar to vary. Movement of the modulation bar is a coarse indication of frequency difference and change of the color sequence within the bar is a precise indication of phase difference.

In a second embodiment, the locally synthesized color subcarrier signal and the color subcarrier signal of the television receiver are compared in a linear phase comparator to develop a signal having an instantaneous voltage proportional to the phase difference between the two signals. The phase signal controls a generator which develops a cursor line on the screen. Movement of the line across the screen provides a coarse indication of phase difference between the subcarrier signals. The phase signal is also applied to a digital counter which affords a precise readout of the phase difference between the signals.

U.S. Patent 3,966,413. **Electrochemical chlorine flux monitor,** G. Marinenko, (June 29, 1976).

Key words: calibration cell; chlorine concentration; chlorine monitor; electrochemical calibration; internal calibration; iodine detection; potassium iodide.

This apparatus for monitoring the chlorine concentration of water has a unique internal calibration capability and a high sensitivity. A water sample is mixed with a solution of potassium iodide and the reaction produces a mole of iodine for every mole of chlorine present in the water. The mixture is passed through a detection and calibration assembly wherein the iodine is detected amperometrically by a detection cell. Calibrant (known) iodine fluxes, equivalent in effect to the unknown chlorine-produced iodine fluxes, are supplied to the detection cell during calibration runs by means of an upstream calibration cell which electrolyzes the iodide (preferably added to distilled water) to iodine at flux rates given simply by the electrolyzing currents divided by Faraday's constant. An electronics package having gain and offset controls and a concentration display is provided.

U.S. Patent 3,967,140. **Tunnel diode pulse generator,** J. R. Andrews, (June 29, 1976).

Key words: directional coupler; fast risetime; flat pulse baseline/topline; pulse generator; step waveform; tunnel diode.

A tunnel diode pulse generator is triggered through a directional coupler. The tunnel diode is coupled across one end of an output transmission line through an impedance matching network which matches the characteristic impedance of the transmission line. Triggering signals are coupled to the transmission line through the directional coupler for propagation of triggering impulses towards the tunnel diode.

U.S. Patent 3,968,363. **Radiation flux averaging device of high efficiency,** K. D. Mielenz, R. Mavrodineanu, and E. D. Cehelnik, (July 6, 1976).

Key words: averaging sphere; averaging ultraviolet and visible light; radiation converter; ultraviolet averaging sphere; ultraviolet to visible converter.

A flux averaging sphere having an improved efficiency and a high averaging and diffusing effectiveness over the visible and ultraviolet ranges. The interior surface of the sphere is coated with a white diffusing material which has a higher reflectance for visible radiation than for ultraviolet radiation. A radiation converting means is disposed inside the sphere for converting incoming ultraviolet radiation to visible radiation before reflections from the sphere wall occur. The radiation converting means is transparent to incoming visible radiation which therefore remains unaffected. The efficiency of the device is further improved by eliminating the small gap between the output area and the face of the photomultiplier tube. The sphere is formed with a tapered tubular extension at the output area and the face of the photomultiplier tube is abutted against the end of the extension thereby forming a substantially light tight seal.

U.S. Patent 3,970,862. **Polymeric sensor of vibration and dynamic pressure,** S. Edelman, S. S. Roth, and J. F. Mayo-Wells, (July 20, 1976).

Key words: dynamic pressure transducer; polymeric film transducer; sandwiched polymeric films; vibration transducer.

A transducer, and method for making it, comprising a composite film for sensing pressure comprising a pair of film sandwiches, each sandwich comprising a poled polymeric films with metallic film electrodes on opposite surfaces. One electrode does not extend quite to the end of the polymer and is considered the "hot" electrode. Two such transducer film sandwiches are cemented together with the hot electrodes in contact with each other, the center wire from a coaxial cable being in contact with and between them. The outer electrodes are electrically connected to the shield of the cable and the connection is encapsulated.

U.S. Patent 3,973,970. **Additive composition for making dental materials,** C. P. Mabie, (Aug. 10, 1976).

Key words: ammonium stabilized silica and alumina sols; colloidal alumina and silica for dental porcelain; dental porcelain; porcelain balling reduction.

Addition of ammonium stabilized colloidal silica, borax and boric acid to the distilled water in which dental porcelain is fired

greatly increases the firing range by reducing "balling" or edge rounding, and flow deformation. Greatly increased machinability and indefinitely prolonged green-biscuit strength is also obtained by the use of the present additive without deleterious effects on the porcelain.

U.S. Patent 3,975,940. **Portable tester for measuring the static coefficient of friction between a floor surface or the like and a shoe sole or heel material or the like,** R. J. Brungraber, (Aug. 24, 1976).

Key words: floor slipperiness; slipperiness tester; static coefficient of friction measurement.

A portable testing device for determining the static coefficient of friction between a floor surface and a shoe sole or heel material includes an upper, weighted strut movable within a vertical plane and a lower strut pivotably secured to the bottom portion of the upper strut. The upper strut is mounted within a bearing block which is translatably movable within a horizontal plane, and the lower strut has secured to the bottom portion thereof a yoke within which a metal shoe carrying a representative shoe sole or heel material to be tested is pivotably secured. The yoke and shoe project through the base of the device framework so as to rest upon the flooring material being tested, and a trigger is disposed near the shoe so as to be actuated thereby upon the occurrence of slip between the shoe and flooring materials. The trigger is in turn connected to a friction clutch which controls the movement of a graduated rod, which is coupled to the bearing block so as to monitor the movement thereof and upon which the static coefficient of friction data is indicated, and upon the occurrence of slip, the movement of the rod is arrested by the clutch mechanism whereby the friction coefficient may be read directly from the rod.

U.S. Patent 3,996,120. **Laser-induced photochemical enrichment of boron isotopes,** S. M. Freund and J. J. Ritter, (Dec. 7, 1976).

Key words: boron isotope separation; boron trichloride; isotope enrichment; laser isotope separation; photochemical enrichment.

A boron trichloride starting material containing both boron-10 isotopes and boron-11 isotopes is selectively enriched in one or the other of these isotopes by a laser-induced photochemical method involving the reaction of laser-excited boron trichloride with either H_2S or D_2S. The method is carried out by subjecting a low pressure gaseous mixture of boron trichloride starting material and the sulfide to infrared radiation from a carbon dioxide TE laser. The wave length of the radiation is selected so as to selectively excite one or the other of boron-10 BCl_3 molecules or boron-11 BCl_3 molecules, thereby making them preferentially more reactive with the sulfide. The laser-induced reaction produces both a boron-containing solid phase reaction product and a gaseous phase containing mostly unreacted BCl_3 and small amounts of sulfhydroboranes. Pure boron trichloride selectively enriched in one of the isotopes is recovered as the primary product of the method from the gaseous phase by a multi-step recovery procedure. Pure boron trichloride enriched in the other isotope is recovered as a secondary product of the method by the subsequent chlorination of the solid phase reaction product followed by separation of BCl_3 from the mixture of gaseous products resulting from the chlorination.

4. TITLES AND ABSTRACTS OF PAPERS PUBLISHED IN NON-NBS MEDIA, 1976

Reprints from the journals listed in this section may often be obtained from the authors. See page 3 for additional information.

15707. Morrissey, B. W., Stromberg, R. R., **Bound fraction measurements of adsorbed blood proteins,** (Proc. American Chemical Society Meeting on Biomedical Applications of Polymers Chicago, IL, Aug. 25-29, 1973), Paper in *Biomedical Applications of Polymers*, H. P. Gregor, Ed., **7,** 57-68 (Plenum Press, New York, NY, 1975).

Key words: blood proteins; infrared bound fraction; protein adsorption; protein conformation.

The likelihood that surface-induced blood coagulation results from specific protein-material interactions has led to a study of the conformation of adsorbed blood proteins. Infrared difference spectroscopy was used to determine the bound fraction, i.e., the fraction of carbonyl groups of an adsorbed molecule directly interacting with the surface, of serum albumin, prothrombin, and fibrinogen in situ. Measurements were carried out on individual proteins as a function of the amount adsorbed, time of adsorption, pD, and ionic strength using a silica surface.

The results obtained for serum albumin and prothrombin indicate that the internal bonding of these globular proteins is sufficient to prevent changes in the structure while adsorbed, even at low surface population. The bound fraction of fibrinogen increases with increasing adsorbance suggesting possible interfacial aggregation. The conformation of all three proteins was found to be independent of the time of adsorption, although major differences in the rates of adsorption were observed.

15708. Flynn, D. R., Pallett, D. S., **Simplified methods for calculating the transmission loss of two-element partitions,** *J. Acoust. Soc. Am.* **58,** No. 6, 1341-1342 (Dec. 1975).

Key words: airborne sound transmission; architectural acoustics; building acoustics; sound reduction index; sound transmission loss; transmission loss.

Three alternative procedures—a table look-up, a nomograph, and a specially devised slide rule, depending on the preference of the user—are given for rapid computation of the sound transmission loss of a composite partition.

15709. Cezairliyan, A., Beckett, C. W., **Measurement of thermal properties at high pressures by transient techniques,** Chapter 7 in *Thermochemistry and Thermodynamics*, H. A. Skinner, Ed., **10,** 247-260 (Butterworths, London, 1975).

Key words: heat capacity; high pressures; thermal conductivity; thermal diffusivity; thermal properties; transient techniques.

Measurements of selected thermal properties (heat capacity, thermal conductivity and thermal diffusivity) at high pressures (up to 100 kbars) using transient techniques are reviewed.

15710. Feldman, A., **Relations between electrostriction and the stress-optical effect,** *Phys. Rev. B* **11,** No. 12, 5112-5114 (June 15, 1975).

Key words: electrostriction; electrostrictive coefficients; free energy; stress-optical constants; stress-optical effect.

Relationships are obtained between the stress-optical constants and the electrostrictive coefficients of solid materials. These results, which are dependent upon the geometric boundary conditions, encompass the apparent differences in the relationships derived by different authors.

15711. Geist, J., **The role of radiometry in solar energy utilization,** *Proc. Smithsonian-Eppley Symp. on Solar Radiation Measurement and Instrumentation, Rockville, MD, Nov. 13-14, 1973*, pp. 79-94 (1973).

Key words: effective irradiance; radiometry; solar energy conversion.

This paper identifies the various radiometric problems that are of importance to solar energy utilization. Some basic definitions are presented, and the effective irradiance is shown to be a fruitful concept. Three different activities of the solar energy community that require effective irradiance data are discussed. Finally, it is shown that these different activities apply different constraints to effective irradiance data; the optimum type of data for one activity not necessarily being at all suitable for the other two activities.

15712. Kelly, G. E., Didion, D. A., A **laboratory test of the modular concept as applied to gas-fired boilers,** (Proc. Conf. on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings, Oct. 7-8, 1974), Paper in *Proceedings of Conference on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings*, D. A. Didion and V. Goldschmidt, Eds., pp. 18-30 (Purdue Research Foundation, Lafayette, IN, Oct. 1974).

Key words: boiler oversizing; efficiency vs. heating load; modular boilers; modular concept; seasonal efficiency.

The modular concept of boiler operation was examined in a laboratory test of five gas-fired, cast iron, hydronic boilers. Four of the boilers, each having an input rating of 85,000 Btu per hour, were arranged so that they could either be operated like a single boiler (i.e., all of the boilers either on or off) or as a modular installation in which the boilers are sequentially fired to match the number in operation with the heating load. The fifth boiler had an input rating of 300,000 Btu per hour and was operated as a single boiler installation. Efficiency vs. heating load curves were obtained for the single boiler installation, the four small boilers run like a single boiler and the modular installation operated with and without water flowing through the "idle" modules. These efficiency curves were then used to theoretically predict the effect of the modular concept and boiler oversizing on the seasonal efficiency of gas-fired heating plants.

15713. Achenbach, P. R., **Status of energy standards for heating, ventilating and air-conditioning systems in buildings,** (Addendum to Proc. of Conf. on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings, Oct. 7-8, 1974), Paper in *Addendum to Proceedings of Conference on Improving Efficiency in HVAC Equipment and Components for Residential and Small Commercial Buildings*, P. Newman, Ed., pp. A134-A142 (Purdue Research Foundation, Lafayette, IN, 1975).

Key words: energy conservation; energy standards for mechanical systems; heating and air-conditioning systems; state energy regulations.

The circumstances in energy supply are described which caused the National Conference of States on Building Codes and Standards to request the National Bureau of Standards in 1973 to develop an interim standard for energy conservation in new buildings. The progress in development of such a standard by NBS and the American Society of Heating, Refrigerating and Air-Conditioning Engineers is chronicled to October 1974. The principal policy issues raised by the preparation of an energy conservation standard which could become the basis for State and local regulations are discussed. The components of heating and air-conditioning systems which are at issue between the NBS and ASHRAE documents for inclusion in the energy conservation standard are identified. The long-range objectives of the Federal Energy Administration in developing energy conservation requirements for buildings are summarized.

15714. Hummer, D. G., Kunasz, P. B., **Migration of excitation in transfer of spectral-line radiation,** *J. Quant. Spectrosc. Radiat. Transfer* **16,** 77-96 (1976).

Key words: diffusion; excitation exchange; radiative transfer; spectral line profiles.

A simple mathematical model is developed for the transfer of energy through a gas by the combined effect of radiative transfer and migration of excitation. The "excitation" is carried through the gas by a succession of atoms which experience resonant excitation exchange; it thus appears to random walk through the medium. The theory developed here is valid when the distance traveled by an atom while excited is much larger than the typical distance at which two atoms can exchange excitation (roughly 10^{-6} cm). The model is expressed in terms of a pair of coupled transport equations for the intensity of radiation and the density of excited atoms, which are solved by means of a generalized discrete-ordinate technique. Extensive numerical results are obtained and discussed in terms of characteristic lengths for the various transfer processes. Substantial effects of migration are seen in both the distribution of excited atoms near the cell windows and the line profile of the emergent radiation for typical laboratory conditions.

15715. Fiori, C. E., Myklebust, R. L., Heinrich, K. F. J., Yakowitz, H., **Prediction of continuum intensity in energy-dispersive x-ray micro-analysis,** *Anal. Chem.* **48,** No. 1, 172-176 (Jan. 1976).

Key words: background; continuous x rays; electron probe microanalysis; energy-dispersive x-ray analysis; lithium-drifted silicon detector.

A method for background prediction in electron-excited energy-dispersive x-ray spectrometry (EDS) is described. This method yields the intensity of the continuous radiation which would be observed by the detector as a function of x-ray photon energy. The method can be incorporated into existing electron probe microanalysis data reduction programs. Tests indicate that the proposed background correction scheme is satisfactory for quantitative analysis.

15716. Chabay, I., Klauminzer, G. K., Hudson, B. S., **Coherent anti-Stokes Raman spectroscopy (CARS): Improved experimental design and observation of new higher-order processes,** *Appl. Phys. Lett.* **28,** No. 1, 27-29 (Jan. 1, 1976).

Key words: CARS; diphenyloctatetraene (dilute solution); four-wave numbering; HORSES; nonlinear optics; Raman spectroscopy.

The development of the optical and electronic arrangement which has permitted the straightforward measurement of coherent anti-Stokes Raman spectra (CARS) and of higher order processes not previously reported is described in this paper. The CARS spectrum of a dilute solution of diphenyloctatetraene in benzene is presented. This spectrum demonstrates the significantly greater signal-to-noise ratio possible with CARS as compared to conventional Raman techniques. Higher-order Raman spectral excitation studies (HORSES) are described which indicate the presence of a six-wave or a second-order four-wave mixing process.

15717. Shine, R., Gerola, H., Linsky, J. L., **Diffusion effects on the line intensities of He I and He II in the solar transition region,** *Astrophys. J.* **202,** L101-L105 (Dec. 1, 1975).

Key words: chromosphere-sun; coronal holes; diffusion; transition region-sun; ultraviolet spectrum-sun.

We develop a heuristic treatment of diffusion in the solar chromosphere-corona transition region. We find that diffusion becomes increasingly important with steeper temperature gradients, in active and quiet regions relative to coronal holes, and with increasing excitation potential. Numerical calculations are made for the resonance lines of He I and He II and show that diffusion can enhance these lines. Thus the helium lines may appear relatively weak in coronal holes due to a weakening of the enhancement mechanism. Most transition region lines will be less affected by diffusion than He I or He II.

15718. Hebner, R. E., Jr., Cassidy, E. C., Jones, J. E., **Improved techniques for the measurement of high-voltage impulses using the electrooptic Kerr effect,** *IEEE Trans. Instrum. Meas.* **IM-24,** No. 4, 361-366 (Dec. 1975).

Key words: automation; electrical measurements; electrooptics; high voltage measurement; Kerr effect; optical coupling; pulse measurement.

The purpose of this paper is to present two methods of accumulating, analyzing, and presenting in real time the data generated by a Kerr system in response to a high-voltage impulse. These methods provide immediate information concerning selected electrical parameters in a form which is easily interpretable by most personnel. The first method uses an electronic counter to determine the number of optical transmittance maxima, i.e., light pulses, during the high-voltage impulse. From this count, the peak value of impulse can be calculated. The second method, which can be more accurate and does provide information concerning waveshape, uses a digital recorder to store the output waveform from the Kerr system. A computer is then used to reconstruct the voltage impulse and to determine such parameters as the peak value and risetime of the impulse.

15719. Hellwig, H., **A review of precision oscillators,** *Proc. 6th Precise Time and Time Interval (PTTI) Meeting, Washington, DC, Dec. 3-5, 1974,* pp. 59-81 (Dec. 1974).

Key words: accuracy; atomic clocks; clocks; crystal oscillator; frequency standards; stability; survey of clocks.

Precision oscillators used in PTTI applications include quartz crystal, rubidium gas cell, cesium beam, and hydrogen maser oscillators. A general characterization and comparison of these devices is given including accuracy, stability, environmental sensitivity, size, weight, power consumption, availability and cost. Areas of special concern in practical applications are identified and a projection of future performance specifications is given. An attempt is made to predict physical and performance characteristics of new designs potentially available in the near future.

15720. Petersons, O., Anderson, W. E., **A wide-range high-voltage capacitance bridge with one PPM accuracy,** *IEEE Trans. Instrum. Meas.* **IM-24,** No. 4, 336-344 (Dec. 1975).

Key words: capacitance measurements; current comparators; current transformers; high voltage bridges; high voltage capacitors; high voltage measurements; impedance bridges.

An impedance bridge for high-voltage capacitance and related measurements to an accuracy of 1 ppm is described and the background research and development which made it possible is documented. The bridge is of the transformer-ratio-arm type, the principal components of which are a comparator and several two-stage transformers. The bridge can be used to measure capacitance ratios over a range from 1/1 to $10^7/1$ with a resolution between 0.1 and 0.25 ppm. The highest accuracies are obtained at the principal power frequencies of 50-60 Hz, but the bridge is usable up to 400 Hz. The factors which limited the accuracy of previously developed bridges of this type were reexamined and their influence reduced. Two independent methods were developed for the calibration of the bridge.

15721. DiMarzio, E. A., Bishop, M., **The nature of the helix-random coil transition of biological macromolecules attached to a surface,** *Biopolymers* **13,** 2331-2348 (1974).

Key words: biopolymers; helix-coil transition; phase transitions in biopolymers; self-assembly; structural transformations; surface adsorption.

The effect of the presence of a surface on the helix-random coil transition is investigated. It is found that a grand canonical ensemble formation used previously to solve exactly the problem of a polymer between two plates can be used to solve approximately the problem of DNA near a plane surface. The formalism is applied to the homogeneous perfect-matching model of infinite molecular weight. A crucial part of the calculation for double-stranded molecules involves the evaluation of the entropy of the loops connecting the helical portions of the double-stranded chains. One obtains as a measure of the configurational freedom of a loop As^j/j^c where c has the following values: for a loop connecting two helical regions both off the surface $c=3/2$; for a loop connecting a helical region on the surface to a helical region off the surface $c=5/2$; for a loop connecting helixes both on the surface $c=4$. Corresponding values for an n-stranded molecule are $c=(3n-3)/2$, $c=(4n-3)/2$, $c=(5n-2)/2$. In all cases, the effect of the surface is to sharpen the transition. In the case of double-stranded molecules, the transition becomes first order. We take the view that self-assembly of biological macromolecules can be considered as a sharp thermodynamic phase transition. Thus, the above systems become models of self-assembling systems. They are also relevant to the problem of surface-induced enzymatic activity.

15722. Heinrich, K. F. J., Yakowitz, H., **Absorption of primary x rays in electron probe microanalysis,** *Anal. Chem.* **47,** No. 14, 2408-2411 (Dec. 1975).

Key words: absorption correction; primary emission; quantitative electron probe analysis; x-ray absorption factor.

Available experimental evidence concerning absorption in x-ray targets, corrected for fluorescence due to the continuum, is generalized to give the formula, $f_p=(1+a\gamma\chi)^{-2}$, in which f_p is the primary x-ray absorption factor, $\gamma=(E_o^{1.65}-E_q^{1.65})$, E_o(kV) is the operating voltage, E_q(kV) the critical excitation voltage, $\chi=\mu$ cosec ψ, μ is the mass absorption coefficient for the respective target and line, ψ is the x-ray emergence angle, and $a=1.2\times10^{-6}$ g/cm^2. The presumed effect of the atomic number of the target on f_p is overestimated by Philibert's formula. It is smaller than the statistical spread of experimental data, and can therefore be neglected.

15723. Mihalas, D., Kunasz, P. B., Hummer, D. G., **Solution of the comoving-frame equation of transfer in spherically symmetric flows. I. Computational method for equivalent-two-level-atom source functions,** *Astrophys. J.* **202,** 465-489 (Dec. 1, 1975).

Key words: atmospheres, stellar; atomic and molecular processes; line formation; radiative transfer.

The equation of radiative transfer in the comoving frame makes possible an economical solution of the line formation problem in spherical atmospheres expanding with arbitrarily large velocities. A stable differencing scheme and a frequency-by-frequency elimination procedure have been developed to solve the partial differential equations that describe the radiation field in the comoving frame. Numerical results were obtained for a large number of illustrative models involving line formation by two-level atoms, electron scattering, and continuous absorption. Selected results that simulate situations in the stellar winds of hot stars and similar objects are discussed. In addition to P Cygni and other very broad profiles, extreme center-to-limb variations are obtained that show both limb darkening and limb brightening. For very high velocity flows with very weak or nonexistent continuum and electron-scattering opacities, the flux profiles are very nearly symmetric about the laboratory wavelength and have shapes reminiscent of those observed in the nuclei of Seyfert galaxies. Comparisons are presented between the results of Sobolev-type escape probability calculations and those obtained here. The force of radiation on the gas is examined in a number of situations; the mechanism mentioned by Noerdlinger and Rybicki for the disruption of radiatively driven envelopes in planar geometries is shown to become inoperative for even slightly extended spherical systems.

15724. McQueen, J. T., Levinsohn, D. M., Waksman, R., Miller, G. K., **The evaluation of the Shirley Highway Express-Bus-on-Freeway Demonstration Project,** *Report DOT/UMTA* **7,** 133 pages (Available as PB247637 from the National Technical Information Service, Springfield, VA 22161, Aug. 1975).

Key words: bus transit; busways; carpools; energy impacts; mode choice; pollution reduction.

The Shirley Highway Express Bus-on-Freeway Project began in June 1971 and ended December 31, 1974. The principal goal of the project was to demonstrate that express bus-on-freeway operations can improve the quality of bus service and lead to an increase in the people moving capability of peak period transportation facilities for an entire urban corridor. Secondary project goals were to demonstrate the effectiveness of this technology as a means of reducing auto pollutant emissions and gasoline consumption, improving the mobility of the transportation disadvantaged and the economic condition of the transit operator.

This report summarizes project performance with respect to the attainment of the above goals. An analysis of bus operations is presented which shows that the project effected an improvement in the quality of the Shirley Highway Corridor bus service as evidenced by the reduction in travel times by bus, and the increase in both the reliability and the coverage of the bus systems. Trends in peak period traffic volumes are presented which show that the subsequent increase in bus patronage and bus' share of Corridor commuters led to an increase in the peak period people moving capability of the Corridor. Corridor people moving capability was also increased by project stimulated growth in carpooling.

Data from surveys of Corridor commuters were used in identifying factors important in commuters' decision to use bus or to carpool. Bus users who formerly had commuted by auto reported

that the most important factors in their decisions to switch from auto were the expense and discomfort of commuting by auto, and the express features of project bus service. Factors reported as most important in decisions to join or form a carpool were reduction in commuting costs, special parking privileges for carpools, and availability of the express busway to carpools.

The report concludes with an analysis of project performance with respect to the secondary goals. The project resulted in significant reductions in peak period auto usage, auto pollutant emissions and gasoline consumption. The utilization of project bus service by transportation disadvantaged persons is discussed and project costs and revenues are analyzed.

15725. Zalubas, R., Reader, J., Corliss, C. H., **$4s^24p^4$-$4s4p^5$ transitions in five-times-ionized yttrium (Yvi),** *J. Opt. Soc. Am.* **66,** No. 1, 35-36 (Jan. 1976).

Key words: spectra; ultraviolet; wavelengths; yttrium.

The spectrum of yttrium has been observed in a sliding spark discharge at peak currents up to 2000 Å on the 10.7 m normal and grazing incidence vacuum spectrographs at NBS. From these observations, the group of $4s^24p^4$-$4s4p^5$ transitions in Yvi, which lie in the region 457-766 Å, has been identified and measured, thus yielding values for the 4 levels of the $4s4p^5$ configuration and revised values for the 5 levels of the $4s^24p^4$ configuration. The energy parameters obtained from a least-squares fit to the observed levels are compared with Hartree-Fock calculations.

15726. Mulholland, G. W., **Self-diffusion through a liquid-vapor interface,** *J. Chem. Phys.* **64,** No. 2, 862-870 (Jan. 15, 1976).

Key words: continuous interface profile; diffusion equation; hypergeometric differential equation; interfacial force; liquid-vapor interface; Markov Stochastic model; self-diffusion.

A diffusion equation containing information about the structure of the liquid-vapor interface is constructed to describe self-diffusion in a one component, two phase fluid. Analysis of the diffusion equation in the limit of vanishing interface thickness leads to interfacial matching conditions, one of which was previously assumed ad hoc. From a study of the asymptotic long time behavior of the equation, it is found that an ordinary self-diffusion experiment can not be expected to provide information about the interface structure. A numerical study of the diffusion equation shows that the reduced time to diffuse through the interface is independent of the ratio of the vapor and liquid densities, which is the one free parameter in the diffusion equation. An experimental test of our prediction that it takes the same time to diffuse from the liquid to the vapor as vice versa is suggested.

15727. Dyer, C. S., Trombka, J. I., Schmadebeck, R. L., Eller, E., Bielefeld, M. J., O'Kelley, G. D., Eldridge, J. S., Northcutt, K. J., Metzger, A. E., Reedy, R. C., Schonfeld, E., Seltzer, S. M., Arnold, J. R., Peterson, L. E., **Radioactivity observed in the sodium iodide gamma-ray spectrometer returned on the Apollo 17 mission,** *Space Sci. Instrum.* **1,** 279-288 (1975).

Key words: Apollo 17; background; cosmic-ray proton; induced radioactivity; secondary neutrons; sodium iodide detector.

In order to obtain information on radioactive background induced in the Apollo 15 and 16 gamma-ray spectrometers (7 cm × 7 cm NaI) by particle irradiation during spaceflight, an identical detector was flown and returned to earth on the Apollo 17 mission. The induced radioactivity was monitored both internally and externally from one and a half hours after splashdown. When used in conjunction with a computation scheme for estimating induced activation from calculated trapped proton and cosmic-ray fluences, these results show an important contribution resulting from both thermal and energetic neutrons produced in the heavy spacecraft by cosmic-ray interactions.

15728. Leep, D., Gallagher, A., **Excitation of the Mg and Mg^+ resonance lines by electron impact on Mg atoms,** *Phys. Rev. A* **13,** No. 1, 148-155 (Jan. 1976).

Key words: electron excitation; magnesium.

We have measured the optical excitation functions and polarizations of the Mg resonance line (2852 Å) and of the Mg^+ resonance lines (2796 Å, 2803 Å, unresolved) arising from ionizing excitation of magnesium atoms, for electron-impact energies from the excitation threshold to 1400 eV. In our crossed-beam apparatus, the electron-beam energy resolution was ≈0.25 eV for energies below 10 eV, and the atom beam was optically thin. The excitation function of the ionic lines was normalized to that of the atomic line by relative intensity measurements. The 2852-Å excitation function, when normalized to Born theory in the high-energy limit, has a maximum cross section of $17.3\pi a_0^2 \pm 3$ percent 18.5 eV. This excitation function is graphically compared with the resonance-line excitation functions of Na, Ca, and Li previously measured in this laboratory. The 2852-Å polarization function is consistent with the theoretical threshold limit of + 100 percent, and has a sharp feature near 5 eV which cannot be due to cascading.

15729. Mahan, A. H., Gallagher, A., Smith, S. J., **Electron impact excitation of the 3*S*, 3*P*, and 3*D* states of H,** *Phys. Rev. A* **13,** No. 1, 156-166 (Jan. 1976).

Key words: electron excitation; hydrogen.

The relative excitation function for electron-impact excitation of H to yield Balmer α has been measured from threshold to 500-eV collision energy in a crossed-beam apparatus. The relative contributions of the $3S$, $3P$, and $3D$ states to this excitation function have been measured by modulating the electron beam and discriminating on the basis of their different lifetimes for radiative decay after excitation. The resulting set of relative $3S$, $3P$, and $3D$ cross sections has been normalized by equating the total measured Balmer-α cross section at 500 eV to the Born approximation. The normalized cross sections are then compared to available theories at lower energies. In contrast to virtually all known excitation cross sections of neutral atoms, which fall below the Born theory at low energies, the H ($1S \rightarrow 3D$) cross section exceeds the Born theory, apparently owing to coupling between the $3D$ and $2P$ states.

15730. Murphy, T. A., Sengers, J. V., Sengers, J. M. H. L., **Scaled parametric equation of state for steam in the critical region,** (Proc. 8th Int. Conf. on the Properties of Water and Steam, Giens, France, Sept. 23-27, 1974), Paper in *Proceedings of the 8th International Conference on the Properties of Water and Steam,* P. Bury, H. Perdon, and B. Vodar, Eds., **1,** 603-613 (Ministère de l'Industrie et de la Recherche, Paris, France, 1975).

Key words: critical density; critical exponents; critical pressure; critical region; critical temperature; equation of state; linear model; scaled equation; steam.

The anomalous thermodynamic behavior of fluids near the critical point can be described in terms of scaling laws. In recent years a parametric equation of state, the so-called Linear Model, has been proposed that satisfies the scaling laws and contains only a small number of adjustable parameters. It is shown that the Linear Model yields a satisfactory representation of the experimental P-V-T data for steam in the critical region.

15731. McCarty, R. D., **The correlation of equilibrium and transport properties of fluids,** (Proc. 8th Int. Conf. on the Properties of Water and Steam, Giens, France, Sept. 23-27, 1974), Paper in *Proceedings of the 8th International Conference on the Properties of Water and Steam,* P. Bury, H. Perdon, and B. Vodar, Eds., **1,** 537-556 (Ministère de l'Industrie et de la Recherche, Paris, France, 1975).

Key words: correlation; equation of state; excess function; hydrogen; interpolation methods; least squares; methane; thermodynamic properties; transport properties.

The practice of using a mathematical model for correlating the transport and thermodynamic properties of fluids is reviewed. Changes which are currently taking place in the field are analyzed from both the correlator's point of view and the people who are going to use the results of the correlation. The present state-of-the-art indicates present and future correlations must be more user oriented than those of the past. A review of correlation methods is given with emphasis on model selection. A new model for the transport property excess function is given. An example of simultaneous data fitting demonstrates the value of this technique.

15732. Johnson, D. P., Guildner, L. A., Jones, F. E., **Vapor pressure of water at its triple point,** (Proc. 8th Int. Conf. on the Properties of Water and Steam, Giens, France, Sept. 23-27, 1974), Paper in *Proceedings of the 8th International Conference on the Properties of Water and Steam,* P. Bury, H. Perdon, and B. Vodar, Eds., **1,** 365-377 (Ministère de l'Industrie et de la Recherche, Paris, France, 1975).

Key words: mercury manometer; triple point of water; vapor pressure.

The vapor pressure of water has been measured at its triple point with a newly constructed apparatus. It was designed to provide a dynamic system with a thin stream of water flowing down an ice mantle, the temperature of which was determined by a standard platinum resistance thermometer. The pressure was measured by the NBS precision mercury manometer, with a diaphragm unit to separate the helium in the manometer from the water vapor. The value found from a series of measurements was 611.636 Pa with an estimated total uncertainty (3 σ limits plus estimate of systematic error) of ± 0.061 Pa.

15733. Sengers, J. M. H. L., **Universality of critical behavior in fluids,** (Proc. 8th Int. Conf. on the Properties of Water and Steam, Giens, France, Sept. 23-27, 1974), Paper in *Proceedings of the 8th International Conference on the Properties of Water and Steam,* P. Bury, H. Perdon, and B. Vodar, Eds., **1,** 56-78 (Ministère de l'Industrie et de la Recherche, Paris, France, 1975).

Key words: critical exponents; critical region; homogeneity; polar fluids; scaling; steam; universality.

Modern developments in the description of critical-region anomalies are reviewed. The concepts of critical exponents, homogeneity, scaling and universality are introduced. The question is raised whether the critical behavior of steam, a polar fluid, can be expected to be the same as that of nonpolar fluids. Theoretical and experimental evidence for an affirmative answer to this question is presented. The consequences for the correlation of properties of steam in the critical region are drawn.

15734. Lide, D. R., Jr., **Cooperation between professional societies and a government agency: The Journal of Physical and Chemical Reference Data,** *IEEE Trans. Prof. Commun.* **PC-18,** No. 3, 127-129 (Sept. 1975).

Key words: journal; professional societies; publications; reference data.

The National Standard Reference Data System consists of data centers and other projects funded or coordinated by the National Bureau of Standards (NBS) which compile and evaluate data on physical and chemical properties of well-defined materials. The output is then published in the form of tables of recommended data and critical reviews. In 1972 an agreement was reached with the American Chemical Society (ACS) and the American Institute of Physics (AIP) for establishing a new publication channel for the material, the *Journal of Physical and Chemical Reference Data.* Editorial work and preparation of camera-ready copy is handled by NBS, while ACS and AIP divide the other responsibilities. The progress of this journal is reviewed.

15735. Choi, C. S., Santoro, A., Marinkas, P. L., **1,3,5-Triacetyl-2,4,6-hexahydro-*s*-triazine (TRAT),** *Acta Crystallogr.* **B31,** Part 12, 2934-2937 (Dec. 15, 1975).

Key words: diffractometer; direct methods; explosives; single-crystal; triazine; x ray.

$C_9H_{15}N_3O_3$, monoclinic, $P2_1/c$, $a=7.772$ (2), $b=15.521$ (4), $c=10.101$ (2) Å, $\beta=116.34$ (2)°, $Z=4$, $D_x=1.30$, $D_m=1.31$ g cm^{-3}, $F(000)=456$. All x-ray measurements were made with Mo $K\alpha$ radiation ($\lambda=0.71069$ Å). The structure was solved by direct methods and refined by full-matrix least-squares calculations to final R and R_w values of 0.051 and 0.035, respectively, for 777 observed reflections.

15736. Hellwig, H. W., **Atomic frequency standards: A survey,** *Proc. IEEE* **63,** No. 2, 212-229 (Feb. 1975).

Key words: application of standards; basic standards; cesium standards; frequency accuracy; frequency stability; frequency standards; hydrogen standards; ion storage; laser stabilization; rubidium standards; saturated absorption; time standards.

The last comprehensive survey on atomic frequency standards was done by McCoubrey. This survey reviews the more recent historical background of atomic frequency standards leading to the present developments. A discussion of the underlying physical and engineering principles is given. Modern atomic frequency standards, including their performance, are compared quantitatively, and projections are attempted at likely future developments and performance characteristics.

As in 1966, the standards principally used in technical and scientific applications are rubidium gas cell devices, cesium beam tubes, and hydrogen maser oscillators. However, substantial advances in physical and performance characteristics can be reported.

New developments include passive hydrogen devices, saturated absorption stabilized lasers, ion storage devices, and atomic beams in the far infrared and infrared region, as well as new techniques to evaluate frequency biases such as those encountered in cesium and hydrogen standards.

The survey includes a discussion of the effects of past and current developments in atomic frequency standards on the technical and scientific user community.

15737. Snyder, N. S., **The Kapitza conductance of the (100) surface of copper,** *J. Low Temp. Phys.* **22,** No. 3/4, 257-284 (1976).

Key words: heat transfer to helium II; interfacial thermal resistance; Kapitza conductance; Kapitza conductance of

copper; x-ray diffraction examination of single crystal lattice damage; (100) surface of copper.

Measurements of the Kapitza conductance to liquid helium II across the (100) surface of single crystals of copper are presented. The temperature range of these measurements was 1.6-2.1 K. The sample surfaces were subjected to several different treatments. Some surfaces were cleaned by low-energy argon ion bombardment, annealed in an ultrahigh-vacuum system, and preserved under vacuum until purified liquid helium was admitted. Other surfaces were intentionally damaged by machining and/or exposure to the atmosphere. The conductance after these latter treatments was found to be about a factor of three higher than that of the more ideally cleaned and annealed surfaces, and a significant difference in the temperature dependence of the conductance was also observed. Conductances were reproducible for similarly treated surfaces and could be correlated with surface damage determined by x-ray diffraction. The relationship of these results to the numerous current theories of the Kapitza conductance is discussed. Conductance measurements of polycrystalline indium, which was used as a sealant, are presented.

15738. Kulin, G., **Simplified application of Palmer-Bowlus flow meters,** *J. Water Pollut. Control Fed. Discussion* **48,** No. 1, 200-201 (Jan. 1976).

Key words: flow measurement, water; flumes, measuring; open channel flow measurement; Palmer-Bowlus flumes; sewage flow measurement.

Possible errors associated with the use of the customary theoretically derived rating curves for Palmer-Bowlus flumes are identified and evaluated.

15739. Lieberman, A. G., **Problems in using surface analysis techniques for the depth profiling of microelectronic materials,** *Technical Digest of International Electron Devices Meeting, Washington, DC, Dec. 1-3, 1975,* pp. 126-129 (1975).

Key words: Auger electron spectroscopy; depth impurity profiling; ion implantation; ion sputtering; microelectronic materials; Rutherford backscattering; secondary ion mass spectroscopy; silicon; silicon dioxide; surface analysis; x-ray photoelectron spectroscopy.

Practical problems associated with the depth profiling of impurity distributions in silicon and silicon dioxide are illustrated for several widely used surface analysis techniques as applied at a number of laboratories. The methods used for depth profiling were Rutherford backscattering spectroscopy, Auger electron spectroscopy and x-ray photoelectron spectroscopy.

15740. Allan, D. W., **The measurement of frequency and frequency stability of precision oscillators,** *Proc. Sixth Annual Precise Time and Time Interval (PTTI) Planning Meeting, U.S. Naval Research Laboratory, Washington, DC, Dec. 3-5, 1974,* pp. 109-142 (Goddard Space Flight Center, Greenbelt, MD, 1974).

Key words: accurate frequency measurement; accurate time measurement; frequency; frequency stability; frequency stability analysis; models of frequency stability; picosecond time difference measurements.

The specification and performance of precision oscillators is a very important topic to the owners and users of these oscillators. This paper presents at the tutorial level some convenient methods of measuring the frequencies of precision oscillators—giving advantages and disadvantages of these methods.

Conducting such measurements, of course, gives additional understanding into the performance of the given pair of oscillators involved. Further it is shown that by processing the data from the frequency measurements in certain ways, one may be able to state more general characteristics of the oscillators being measured. The goal in this regard is to allow the comparisons of different manufacturers' specifications and more importantly to help assess whether these oscillators will meet the standard of performance the user may have in a particular application.

The methods employed for measuring frequency are designed for state-of-the-art oscillators, and an effort has been made to allow for fairly simple, inexpensive, and/or commonly available componentry to be used in the measurement systems. The method for measuring frequency stability is basically that recommended by the IEEE subcommittee which wrote the paper "Characterization of Frequency Stability," IEEE Transactions on Instrumentation and Measurement, IM-20, No. 2, pp. 105-120, (May 1971).

15741. Powell, F. J., **The Manchester, N.H., experimental energy office building,** (Proc. Seminar on Energy Conservation by Design, Orlando, FL, March 20-21, 1974), Paper in *Proceedings Energy Conservation—By Design, Section 14, 1-14 (Harry Phipps, Energy Systems Consultants, St. Petersburg, FL, 1974).*

Key words: energy conservation; energy consumption prediction; experimental office building.

A brief background of the experimental 7-story Federal Energy Demonstration Office Building to be Constructed at Manchester, N.H. is given. A summary of the results of a predesign energy analysis done at NBS is presented as a comparison of normal General Services Administration practice in 1972 with changes made for a new energy conservation design approach. A similar comparison is made for the same building if the location were changed to Orlando, Fla. The results indicate annual energy savings of 52 percent for Manchester and 39 percent for Orlando are possible by using additional thermal insulation in the roof, walls and floor, reducing the window area, reducing the quantity of ventilation and lighting power, and using energy efficient heating, ventilating and air-conditioning systems.

15742. Fowlkes, C. W., **Crack opening interferometry—The effects of optical refraction,** *Eng. Fract. Mech.* **7,** 689-692 (1975).

Key words: cracks; experimental mechanics; fracture; fracture toughness; interferometry; model experiments; stress; stress intensity.

This paper contains an analytical prediction of the distortions of interference fringes near a crack tip resulting from refraction of the light rays due to the stress field. The effects of these distortions on the results of crack opening interferometry (COI) experiments for determining stress intensity factors are discussed.

15743. Howard, C. J., Evenson, K. M., **Rate constants for the reactions of OH with CH_4 and fluorine, chlorine, and bromine substituted methanes at 296 K,** *J. Chem. Phys.* **64,** No. 1, 197-202 (Jan. 1, 1976).

Key words: gas reactions; hydroxyl radical; kinetics.

The absolute rate constants for the reactions of OH radicals with CH_4 and fifteen fluorine, chlorine, and bromine substituted methane molecules have been measured using a discharge flow system and laser magnetic resonance detection of OH. Measurements were made at 296 K and at pressures between 107 and 1300 Pa. The results indicate that the reaction mechanism involves the abstraction of a hydrogen atom and formation of H_2O

and a methyl type radical product. Completely halogenated methane molecules are found to be relatively unreactive. Hydrogen containing molecules react with rate constants ranging from about 0.2 to 160×10^{-15} cm^3/molecule·sec. The reactivity increases with decreasing carbon-hydrogen bond energies. Rough estimates are made of the Arrhenius parameters for the reactions.

15744. Currie, L. A., Lindstrom, R. M., **The NBS measurement system for natural argon-37,** (Proc. Noble Gases Symp., Las Vegas, NV, Sept. 24-28, 1973), Paper in *Noble Gases*, R. E. Stanley and A. A. Moghissi, Eds., CONF-730915, pp. 40-57 (U.S. Environmental Protection Agency, Las Vegas, NV, Dec. 1975).

Key words: Ar-37; atmospheric radioactivity; cosmic-ray reactions; exponential distribution; low-level counting; noble gas separation; on-line computer; pulse shape discrimination; tropospheric mixing.

A project to determine the cosmic-ray production rate and the natural levels of 35-day half-life ^{37}Ar in the atmosphere has been underway at the National Bureau of Standards for about the past year. The prime objective of this project is to determine the spatial dependence of ^{37}Ar production in the atmosphere, and the spatial distribution of the naturally-produced ^{37}Ar (observed concentrations). The results of this study are to be used, in cooperation with L. Machta (National Oceanographic and Atmospheric Administration), to derive information about atmospheric mixing. The purpose of this communication, however, is to present a general description of the various components of the measurement system.

As the lowest concentrations of interest are but $\cong 10^{-3}$ dpm (^{37}Ar)/l-Ar, very high sensitivity measurement techniques are required. Among the techniques which we have adopted are: quantitative separation of the noble gases from about 1 m^3 of air, using a CaC_2 reactor; gas chromatographic separation of the argon fraction; isotopic enrichment (by a factor of $\cong 100$) of purified argon; use of specially selected low-level gas proportional counters together with massive shielding and anticoincidence meson cancellation; and the application of pulse discrimination based upon both amplitude (energy) and pulse shape. Finally, on-line computer techniques are being applied for data acquisition and system control.

15745. Kasen, M. B., **Properties of filamentary-reinforced composites at cryogenic temperatures,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **580,** pp. 586-611 (1975).

Key words: boron; cryogenics; glass; graphite; literature review; PRD-49; reinforced aluminum; reinforced plastics; structural composites; tensile moduli; tensile strength; thermal conductivity; thermal contraction.

This paper presents a review of a series of significant publications on the mechanical and thermal properties of filamentary-reinforced structural composites in the cryogenic temperature range. The objective, scope of work, and significant conclusions of the selected works are discussed. The temperature dependence of the ultimate tensile strength, tensile modulus, thermal conductivity, and thermal contraction (expansion) is presented for selected composites developed in each program. Problem areas are defined and suggestions are made for future work.

15746. Mies, F. H., **Optical pumping by solar radiation in comets: Polarization of the Na resonance lines,** *Astrophys. J.* **202,** 823-831 (Dec. 15, 1975).

Key words: atomic and molecular processes; comets; line formation; polarization; quantum mechanics.

At some distance from the nucleus of a comet, the rate of fluorescent scattering of solar radiation by an atom or molecule will be comparable to, or exceed, the rate of collisional relaxation. This is the condition for optical pumping. If the ground state has fine structure or hyperfine structure, then significant nonequilibrium distributions of these levels can result, and the fluorescence spectrum can deviate markedly from the laboratory spectrum. In particular, since the incident solar radiation is unidirectional, the pumping causes an *alignment* of the hyperfine magnetic sublevels along the incident axis, and observations from the Earth should exhibit an enhanced linear polarization in the Sun-Comet-Earth plane. Therefore, polarization measurements can be used as a diagnostic for the presence or absence of collisional relaxation. Conditions are especially favorable for the enhanced polarization of the Na D_2 resonance line, and, at a scattering angle of 90°, detailed calculations are presented which predict a polarization of 16 percent, and under favorable circumstances as much as 21 percent, as compared with 10.5 percent for a collisionally equilibrated Na gas.

15747. Kuyatt, C. E., **Observation of polarized electrons by Davisson and Germer,** *Phys. Rev. B* **12,** No. 10, 4581-4583 (Nov. 15, 1975).

Key words: electron polarization; electron scattering; low energy; nickel; single crystals; tungsten.

Early attempts to observe electron polarization in the scattering of low-energy electrons from solids are reviewed. It is found that results published by Davisson and Germer in 1929 were analyzed incorrectly, and that they had in fact observed significant electron polarizations in the diffraction of low-energy electrons from single-crystal nickel.

15748. Gadzuk, J. W., **Angle-resolved photoemission from crystal-field split *d* shells of adsorbed atoms,** *Phys. Rev. B* **12,** No. 12, 5608-5614 (Dec. 15, 1975).

Key words: adsorption; angular distributions; photoemission; photoionization.

A theory of the angular distribution (AD) of photoemitted electrons from filled d shells of atoms adsorbed on solid surfaces is presented. The crystal field at the surface of the substrate splits the degenerate d states of the adsorbate into at least e_g and t_{2g} components. The angular distribution is then calculated for photoemission from the e_g group (since the distribution from the t_{2g} group is easily related to this). The final state is written as a partial-wave sum. For photoelectron kinetic energies less than about 10 eV, transitions from d to p partial waves dominate the AD and these AD's are azimuthally symmetric (for unpolarized light at normal incidence). Above 10 eV, the delayed onset (due to passing over the centrifugal barrier) of d to continuum f partial-wave emission occurs and this channel then dominates. The d_{x2-y2} initial state, composed of spherical harmonics $Y_{2\pm2}$ is connected to $Y_{3\pm3}$ and $Y_{3\pm1}$ partial waves by the dipole operator. The calculated differential cross section, of the form $d\sigma/d\Omega = a(\theta) - b(\theta)\cos 4\phi$, is fourfold symmetric, as expected, owing to interference effects between the $m = \pm 1$ and $m = \pm 3$ partial waves. The anisotropy parameter $\alpha(\theta) \equiv b(\theta)/a(\theta)$ changes sign at $\theta = 63.43°$ and this manifests itself as a 45° azimuthal rotation of the fourfold pattern. Specific systems for studying this effect experimentally are discussed. The deposition of Cu, Ag, or Au on a wide-band-gap insulator such as LiF appears promising as LiF should provide a large crystal field and the noble-metal d states should fall within the gap, thus remaining sharp and resolvable. The importance of the partial-wave interferences in other angle-resolved photoemission studies of oriented atoms, molecules, and surfaces is noted.

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15749. Gadzuk, J. W., **Extra-molecular relaxation energies for H_2 embedded in an electron gas,** *Chem. Phys. Lett.* **36,** No. 5, 606-610 (Dec. 15, 1975).

Key words: molecular hydrogen; photoelectron spectroscopy; polarization energy; relaxation energy; screening energy.

The screening energy associated with a bonding orbital hole state in an H_2 molecule embedded in an electron gas has been calculated, within a linear response formalism. The relationship between this energy and the atomic screening energy is determined and the role of the bonding charge density is emphasized.

15750. Swanson, N., Celotta, R. J., **Observation of excited states in ozone near the dissociation limit,** *Phys. Rev. Lett.* **35,** No. 12, 783-785 (Sept. 22, 1975).

Key words: electron energy loss; forbidden transitions; ozone; triplet states.

Several calculations suggest that the lowest triplet states of ozone lie near the dissociation limit. Using electron energy-loss spectroscopy, we have observed a broad feature beginning at 1.3 eV, with a maximum at 1.65-eV energy loss. This structure is present only under large momentum-transfer conditions, indicative of the excitation of optically forbidden states. Together with the calculations, these data demonstrate that one or more excited states of ozone exist which are stable against dissociation.

15751. Huebner, R. H., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Energy absorption by N_2O in the 4 to 14 eV region,** *J. Chem. Phys.* **63,** No. 10, 4490-4494 (Nov. 15, 1975).

Key words: electron energy loss; energy absorption; N_2O; nitrous oscillator strength; photoabsorption.

Apparent oscillator-strength values for transitions in the 4 to 14 eV region in nitrous oxide have been derived from electron energy-loss measurements. Detailed comparison with photoabsorption measurements in the ultraviolet region indicates a weak transition below the $^1\Delta \leftarrow \bar{X}^1\Sigma^+$ transition at 6.8 eV not observed optically. This analysis also provides oscillator-strength values in the region between 11.5 and 12.4 eV, where no quantitative photoabsorption data are available.

15752. Penn, D. R., **Measurement of the surface density of states by field ionization,** *Surf. Sci.* **52,** 270-276 (1975).

Key words: field ion energy distribution; field ionization; surface density of states; tungsten.

It is shown that recent measurements of field ion energy distributions from clean tungsten surfaces probe the density of metal states in the vicinity of the surface. We find $j(\omega) = (2\pi/\hbar)\Sigma_m |\int d^3r \psi_m(\mathbf{r})\, \gamma(z)|^2\, \delta(\omega - \epsilon_m)$, where $j(\omega)$ is the ion current at energy ω, ψ_m and ϵ_m are electronic metal eigenfunctions and eigenvalues in the presence of the external electric field used in field ionization and $\gamma(z)$ is a function which is large near the noble gas atom. An explicit expression for $\gamma(z)$ is given in the text. It is estimated that tungsten metal states with values of $\mathbf{k}_{||}$ at least as large as 0.5 $Å^{-1}$ make an appreciable contribution to $j(\omega)$ where $\mathbf{k}_{||}$ is the electron momentum parallel to the surface.

15753. Cabana, A., Laurin, M., Pépin, C., Lafferty, W. J., **High-resolution infrared spectrum of the ν_3 and $\nu_2 + \nu_3 - \nu_2$ bands of $^{14}N^{16}O_2$,** *J. Mol. Spectrosc.* **59,** 13-27 (1976).

Key words: infrared spectrum; nitrogen dioxide, ν_3 band; nitrogen dioxide, $\nu_3 + \nu_2 - \nu_2$ band; rotational constants; spectroscopic constants; spin-rotation constants.

The infrared absorption spectrum of the ν_3 band of $^{14}NO_2$ has been recorded with a resolution and a frequency accuracy much improved over the previous investigations. The K- and N-line assignments have been greatly extended and a more accurate set of spectroscopic constants derived. Several lines in the subbands with $K_a \geq 3$ have been observed to be doubled by spin-rotation interaction and spin-rotation interaction constants have been obtained. Several weak series of lines in the spectrum ($K_a = 0, 1, 2,$ and 3) have been unambiguously assigned to the "hot band" $\nu_2 + \nu_3 - \nu_2$. Lines of the $K_a = 3, 4, 5,$ and 6 subbands of ν_3 have been found to be perturbed by a Coriolis interaction with the $K_a = 4, 5, 6,$ and 7 levels of $2\nu_2$.

15754. Mielenz, K. D., Cehelnik, E. D., McKenzie, R. L., **Elimination of polarization bias in fluorescence intensity measurements,** *J. Chem. Phys.* **64,** No. 1, 370-374 (Jan. 1, 1976).

Key words: emission anisotropy; fluorescence; fluorescence decay; fluorescence quantum yields; polarization; spectrofluorimetry; viewing angle.

It is proposed theoretically and confirmed experimentally that, if the fluorescence emission from a polarized sample is viewed in the horizontal plane at an angle of 45° (or 135°) to the direction of propagation of the exciting radiation with a polarizer set at 54.75° (or 125.25°) from the vertical direction, then, the reading obtained is proportional to the total flux emitted by the sample and is independent of the state of polarization of the exciting radiation and the emission anisotropy of the sample. The polarization sensitivity of the emission detection system then becomes a factor which is included in the spectral sensitivity curve of the emission detection system.

15755. Huebner, R. H., Bushnell, D. L., Jr., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Ultraviolet photoabsorption by halocarbons 11 and 12 from electron impact measurements,** *Nature* **257,** No. 5525, 376-378 (Oct. 2, 1975).

Key words: electron energy loss; electron impact; Freon 11; Freon 12; uv photoabsorption.

Electron energy loss measurements are made of Freons 11 and 12. The data is converted to oscillator strength distributions and compared to the existing photoabsorption data in the energy range relevant to atmospheric photodissociation.

15756. Hahn, M. H., Robinson, H. E., Flynn, D. R., **Robinson line-heat-source guarded hot plate apparatus,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 544,* pp. 167-192 (1974).

Key words: conduction; energy conservation; heat transfer; insulation; thermal conductivity; thermal insulation.

This paper presents a description of the line-heat-source guarded hot plate apparatus conceived by the late H. E. Robinson, the results of mathematical analyses of potential sources of uncertainty, and the design of an apparatus of this type being constructed at the National Bureau of Standards. This design utilizes a line source heater, from which heat diffuses laterally in the plate. Such a design does not produce a wholly uniform plate temperature, but does enable calculation of average plate surface, and edge, temperatures utilizing only a few temperature sensors.

15757. Jacox, M. E., **Matrix isolation study of the products of the interaction between metastable Ar and Kr atoms and chloroform. Photodecomposition of $HCCl_2^+$ and $HCCl_2^-$,** *Chem. Phys.* **12,** 51-63 (1976).

Key words: Ar metastable interactions; $ClHCl^-$; emission spectrum; HAr_n^+; $HCCl_2^+$; $HCCl_2^-$; $HCCl_3$; infrared spectrum; matrix isolation; molecular rotation in solid Ar; photoinduced proton transfer; ultraviolet spectrum.

The emission spectrum of a microwave discharge through argon and the infrared and ultraviolet spectra of the products of the interaction of $HCCl_3$ with the periphery of such a discharge, observed after rapid quenching in an argon matrix at 14 K, indicate that metastable argon atoms play an important role in matrix isolation experiments using such a discharge configuration to produce free radicals and molecular ions. Exceptionally high yields of $HCCl_2^+$ and $HCCl_2^-$ and a significant concentration of CCl_3^+ were stabilized in these experiments. The observations support the earlier assignment of the 1037 cm^{-1} peak to "isolated" CCl_3^+. Upon exposure of the sample to 370-280 nm radiation, a prominent, slightly perturbed absorption of $ClHCl^-$ appeared at 705 cm^{-1}. This absorption was destroyed by 280-260 nm radiation. The relative stability of both $HCCl_2^+$ and CCl_3^+ upon exposure of the sample to radiation of wavelength longer than 280 nm is attributed to electron scavenging by the $HCCl_3$ in the matrix; this species is present in considerably greater concentration than are the ion products. Evidence is presented for the photodecomposition of $HCCl_2^+$ at wavelengths shorter than about 280 nm. A marked increase in the concentration of HAr_n^+ when $HCCl_2^+$ was photolyzed by radiation of wavelength shorter than 260 nm is consistent with the calculated threshold energy for proton transfer from $HCCl_2^+$ to Ar. The results of krypton matrix experiments are also consistent with this mechanism. Unstructured absorption bands near 285 and 250 nm are tentatively attributed to $ClHCl^-$ and $HCCl_2^+$, respectively. An increase in the concentration of "nonrotating" H_2O, compared to H_2O molecules free to undergo rotational transitions, when ions are present in the matrix can be attributed to the electric field produced by ionic interactions.

15758. Gadzuk, J. W., **Interaction of atoms and molecules with surfaces,** Chapter 7 in *Surface Physics of Materials*, J. M. Blakeley, Ed., **II,** 339-375 (Academic Press, Inc., New York, NY, 1975).

Key words: adsorption; chemisorption; electronic properties of solids; molecules; surfaces.

The theory of chemisorption of atoms and molecules on surfaces is considered. Emphasis is directed towards the Anderson model (self-consistent molecular orbital theory) and the dielectric screening models. The techniques of group orbitals are used to reduce the many atom problems to one involving a surface molecular complex. Specific cases of H adsorbed on the (100) face of W, alkali atoms on metals, and 5d transition metal atoms on W are treated.

15759. Gadzuk, J. W., **Angle resolved photoemission from chemisorbed layers: Further theoretical considerations,** *Surf. Sci.* **53,** 132-143 (1975).

Key words: angular distributions; chemisorption; electron spectroscopy; photoemission.

In recent theoretical work by Gadzuk and by Liebsch, the importance of angle resolved photoemission studies of surfaces and chemisorbed atoms has been demonstrated. In the theory due to Gadzuk, the role of the initial state in the photoemission process has been emphasized, whereas in the theory due to Liebsch, the role of the final state is stressed in determining a photoemission angular distribution (PAD) from chemisorbed atoms. Here it is shown what conditions favor initial versus final state dominance. In both theories, the PAD is calculated for an isolated chemisorbed atom or surface molecule complex. It is shown how two-dimensional band effects due to adatom–adatom interactions modify (or do not modify) the PAD.

15760. Mahan, A. H., Gallagher, A., **Transition radiation for the diagnosis of low-energy electron beams,** *Rev. Sci. Instrum.* **47,** No. 1, 81-83 (Jan. 1976).

Key words: electron optics; transition radiation.

Electron bombardment of metallic silver is known to produce "transition radiation," predominantly at 300-450 nm wavelengths. In reported measurements at 15-500 eV impact energies, transition radiation was used to diagnose the shape and time dependence of an rf modulated electron beam. It is suggested that this is a superior target, as opposed to phosphors or gases normally used, to determine instrumental time response functions and electron beam imaging.

15761. Truhlar, D. G., Poling, R. E., Brandt, M. A., **Infinite-order sudden approximation for rotational excitation of hydrogen molecules by electrons in the energy range 10-40 eV,** *J. Chem. Phys.* **64,** No. 2, 826-829 (Jan. 15, 1976).

Key words: differential cross sections; elastic scattering; electron scattering; hydrogen molecules; momentum transfer; rotational excitation; scattering theory; sudden approximation.

Electron scattering by H_2 is treated using a noncentral interaction potential including short-range and long-range static contributions, exchange, and polarization effects. The molecule is treated as a rigid rotator and the scattering is treated in the infinite-order sudden approximation. The results show that the rotational excitation cross section exceeds the elastic scattering cross section at large scattering angles at intermediate energies but not at small angles at low energies.

15762. Burch, D. M., Peavy, B. A., Powell, F. J., **Comparison between measured and computer-predicted hourly heating and cooling energy requirements for an instrumented wood framed townhouse,** *ASHRAE Trans.* **81,** Part II, Paper No. 2363, 70-88 (1975).

Key words: building heat transfer; computer programs; dynamic thermal performance; heat flow analysis; heating and cooling loads; thermal analysis; transient heat flows.

A sophisticated computer program called NBSLD was validated for predicting the hourly heating and cooling loads of a residence. An instrumented four-bedroom townhouse was exposed to simulated winter and summer conditions inside a large environmental laboratory. During the tests, the activities of a six member family were simulated, and the inside temperature of the test house was maintained at approximately 75 °F (23.9 °C). Hourly heating and cooling input energy was measured and compared with corresponding computer-predicted values. The NBSLD computer program predicted maximum heating and cooling input loads within 9.2 percent, and energy requirements within 8.2 percent.

15763. Johnson, C. R., **A local Lyapunov theorem and the stability of sums,** *Linear Algebra and Appl.* **13,** 37-43 (1976).

Key words: cone; Lyapunov's theorem; stable matrix.

We present a "local" analog of Lyapunov's theorem which characterizes n by n matrices whose eigenvalues lie in the open left half plane. This allows the characterization of pairs of stable matrices A, B such that the sum $A+\alpha B$ is stable for all real $\alpha > 0$.

15764. Ives, L. K., Ruff, A. W., Reed, R. P., **An electron microscope study of the Tishomingo meteorite,** (Proc. 32d Annual Meeting of Electron Microscopy Society of America, St. Louis, MO, Aug. 13-15, 1974), Paper in *Proceedings Electron Microscopy Society of America, 32d Annual Meeting*, C. J. Arceneaux, Ed., pp. 520-521 (Claitor's Publ. Div., Baton Rouge, LA, 1974).

Key words: alloy; austenite; electron microscopy; iron-nickel; martensite; meteorite; Tishomingo.

Transmission electron microscope studies have been performed on the Tishomingo meteorite. The microstructure consists of original austenite material and transformed martensite. Deformation twins have been observed. High dislocation density was found within the austenite. Heating stage experiments were performed to investigate thermal response of the material.

15765. Fraker, A. C., **Microstructural and corrosion studies of the Ti-2 wt.% Ni alloy,** (Proc. 32d Annual Meeting of Electron Microscopy Society of America, St. Louis, MO, Aug. 13-15, 1974), Paper in *Proceedings Electron Microscopy Society of America, 32d Annual Meeting,* C. J. Arceneaux, Ed., pp. 516-517 (Claitor's Publ. Div., Baton Rouge, LA, 1974).

Key words: corrosion; microstructures; titanium.

The influence of heat treatment on the Ti-2wt.% Ni alloy microstructure was studied. Heat treating above the $\alpha+\beta$ temperature region and quickly cooling produces a martensite type microstructure with a highly segregated Ti_2Ni precipitate phase. Heat treating at lower temperatures results in an enlarged α-titanium grain structure with large randomly dispersed Ti_2Ni precipitates. Transmission electron microscopy, electron diffraction and light microscopy were used to show these microstructural differences as well as examples of local corrosion at the precipitate.

15766. Coriell, S. R., Hurle, D. T. J., Sekerka, R. F., **Interface stability during crystal growth: The effect of stirring,** *J. Cryst. Growth* **32,** No. 1, 1-7 (Jan. 1976).

Key words: alloy; boundary layer; fluid flow; interface; solidification; stability.

The influence of stirring on the morphological stability of a solid-liquid interface during the unidirectional solidification of a binary alloy at constant velocity is calculated on the basis of a model that employs a stagnant solute boundary layer. For fixed values of the growth velocity, temperature gradient, and concentration gradient at the interface, stirring decreases morphological stability. Further, the wavelength at which instability first occurs is greater with stirring than in the absence of stirring. For a fixed growth velocity and temperature gradient, and a bulk liquid of given composition, the effect of stirring decreases morphological stability for a distribution coefficient $k > 1$ but can either increase or decrease stability for $k < 1$. The dependence of critical wavelength on growth velocity measured by Morris and Winegard for Pb-Sb alloys can be explained by this theory.

15767. deWit, R., **Partial disclinations,** *J. Phys. C: Solid State Phys.* **5,** 529-534 (1972).

Key words: crystal; disclination; dislocation; pseudopentagonal; stacking fault; twin; wedge.

A twin in a crystal can terminate at a partial wedge disclination. This is the analogue to a stacking fault terminating at a partial dislocation. It is illustrated for an FCC crystal. Similarly, several twins can terminate at a partial disclination. This is also illustrated for an FCC crystal. Crystals with such defects, which are called pseudopentagonal twins, have been observed. Their x-ray diffraction pattern should show the elastic distortion of the disclination.

15768. Bennett, L. H., McAlister, A. J., Cuthill, J. R., Erickson, N. E., Watson, R. E., **Electronic density of states of lanthanum-transition-metal alloys of $CaCu_5$ type,** *Phys. Rev. B Comments and Addenda* **12,** No. 11, 5335-5337 (Dec. 1, 1975).

Key words: alloys; copper; electronic density of states; lanthanum; nickel; nuclear magnetic resonance; platinum; x-ray photoemission.

Pt-site Knight shifts for the alloy system $LaCu_{5-x}Pt_x$ ($0 < x \leq 5$), and x-ray photoemission data for Pt, $LaNi_5$, and $LaPt_5$ are presented. Variation of the electronic structure of La-transition-metal alloys of $CaCu_5$ type with alloying at the transition-metal sites is discussed in the light of these results and earlier data on the $LaNi_{5-x}Pt_x$ system.

15769. Berger, R. E., **Impact testing of ophthalmic lenses: Stress distribution and the "search" theory,** *J. Am. Optom. Assoc.* **47,** No. 1, 86-92 (Jan. 1976).

Key words: fracture; glass; impact; ophthalmic lenses; stress distributions.

Elementary concepts in fracture mechanics, stress analysis, and impact are discussed as they pertain to fracture of lenses in drop ball testing. Quasi-static estimates for stress distributions during impact are obtained. These profiles show a sharp peak in the tensile stress under the impact point.

Identical groups of lenses were impact tested in two different modes: (1) 25 impacts at a single spot on the lens, (2) 1 impact at each of 25 different spots. Much more breakage was observed in the latter group.

Both the experimental and analytical considerations lend support to the "search" theory of drop ball testing—fracture occurs when the ball strikes a weak spot (where there exists a sufficiently severe flaw) on the lens. Lenses which pass an impact test may well have dangerous flaws away from the impact point.

15770. Johnson, C. R., **Numerical location of the field of values,** *Linear and Multilinear Algebra* **3,** 9-14 (1975).

Key words: *D*-stable matrix; field of values; Gersgorin's theorem; nonnegative matrix; Perron-Frobenius eigenvalue; spectrum of a square complex matrix.

We give an estimate of the angular location of the *field of values*

$$F(A) = \{x^*Ax : x^*x = 1, x \epsilon C^n\}$$

via the Perron-Frobenius root of a nonnegative matrix obtained from A. This estimate is invariant under diagonal congruences of A and may be used to sharpen an existing inclusion region for $F(A)$. Employing a result of Wielandt, an application is also made to the location of spectra of products of matrices based only on regions simply obtained from the factors individually.

15771. Yakowitz, H., **Energy dispersive x-ray spectrometry,** *J. Microscopie Biol. Cell.* **22,** No. 2-3, 137-150 (1975).

Key words: elemental distribution; energy dispersive x-ray analysis; light element analysis; scanning electron microscopy; thin film x-ray analysis; x-ray continuum radiation.

An energy dispersive x-ray spectrometer (EDS) was first used for electron microanalysis in 1968. Since then the number and quality of EDS systems has steadily and rapidly increased. Today a large majority of scanning electron microscopes (SEM) and many transmission electron microscopes (TEM) are equipped with EDS facilities. Thus, the electron microscopist can perform qualitative and quantitative analyses and can also map elemental distribution in the area scanned by the electron beam.

This paper will provide only a brief overview of the operating principles and required equipment for EDS systems. Major emphasis will be placed on data interpretation including

background correction, pulse pile-up effects, peak interferences and analytical schemes for quantitation.

15772. Peterlin, A., Olf, H. G., **Environmental effects on low temperature crazing of crystalline polymers,** *J. Polym. Sci. Part C:* No. 50, 243-264 (1975).

Key words: crazing; cryogenic temperatures; crystalline polymers; environmental effects on crazing; fractional free volume; glass transition temperature; smectic polypropylene; spherulitic polypropylene.

The ductile behavior of crystalline polymers between liquid nitrogen and room temperatures is primarily due to enhancement of crazing by the presence of gases (N_2, A_2, O_2, CO_2) of high thermodynamic activity, i.e., close to their condensation point. Without the presence of such a gas, at temperatures sufficiently above its condensation point so that its activity has dropped to a few percent, the crystalline material is rather brittle although some very limited crazing can be detected. As expected, the ductility and the amount of crazing are very nearly the same in helium as under vacuum. The crazes in smectic PP are extremely long, often traversing the entire width (0.5 cm) of the sample, and generally very similar to crazes in glassy amorphous polymers. They are thin and become thicker at higher temperatures. In monoclinic PP with well developed spherulitic structure, crazing occurs along spherulite diameters that are perpendicular to the stress direction but not along the boundaries between spherulites. In general, the length of a craze equals the spherulite diameter. At low temperatures all crazes originate on the outer surface of the sample which is in direct contact with the gas.

The action of the gas is due to two mechanisms. First, the adsorbed gas reduces the surface energy of the polymer, facilitating the creation of a new surface in the holes and voids of the craze. Second, the gas becomes highly absorbed at the tip of an incidental flaw or of an existing craze, since these are regions of high dilatant stress. The locally absorbed gas acts as a plasticizer easing the flow involved in the nucleation and growth of the craze, i.e., in the formation of fibrillar material of the craze.

15773. Carroll, J. J., Smit, J., Melmed, A. J., **Field-ion imaging of titanium and effects due to hydrogen,** *Surf. Sci.* **45,** No. 2, 640-648 (Oct. 1974).

Key words: field-ion microscopy; hydrogen; titanium.

Titanium specimens of nominal 99.99+ percent purity were prepared and imaged in the field-ion microscope between 23-30 K using hydrogen, hydrogen-helium mixtures, and neon imaging gases. Micrographs obtained in the presence of hydrogen show features that may indicate the early stage development of cracks and hydrides, mostly on and between the $\{11\bar{2}0\}$ and $\{10\bar{1}0\}$ plane regions. Neon field-ion microscopy shows that the image features due to hydrogen-titanium interactions in the field-ion microscope are confined to about 10-15 topmost metal layers.

15774. McKee, R. A., Stark, J. P., **Interpretations for thermomigration results in aluminum and aluminum alloys,** *Acta Metall.* **23,** 1145-1148 (Oct. 1975).

Key words: alloys; aluminum; copper-aluminum; nonisothermal diffusion; silver-aluminum; thermomigration; vacancies.

Recent anomalies have been reported for thermomigration results in aluminum and aluminum alloys. A sign reversal for the measured heat of transport and consequently a mass flux reversal in the thermomigration experiment was reported for self-thermomigration in pure aluminum and for thermomigration of copper in aluminum. These events occurred as a result of varying the grain or crystal size in the experiment. A grain size effect on the measured heat of transport for silver in aluminum has also been reported. Experimental data for nonisothermal diffusion of Ag^{110} in aluminum has established the existence of stable point defect concentrations in excess of those predicted for thermal equilibrium and the explanation for the anomalies in aluminum thermomigration experiments is now possible.

15775. Peterlin, A., **Optical effects in flow,** *Annu. Rev. Fluid Mech.* **8,** 35-55 (1976).

Key words: flow with longitudinal gradient; flow with transverse gradient; optical anemometry; optical birefringence; optical excess tensor; optical mapping of flow; stress excess tensor; two-dimensional flow.

A critical survey of optical effects induced by flow is given for pure liquids, liquid mixtures, suspension and polymer solutions. The optical and stress excess tensors are proportional in pure liquids, mixtures, and polymer solutions and melts in almost the full range of flow gradient (rheo-optical law). Such a proportionality exists also for suspensions at small gradient as long as the birefringence is a linear function of the gradient.

Optical birefringence is used for the mapping of stresses on a flow field in complicated flow geometry and particularly with non-Newtonian fluids. The Doppler effect of scattered light is used for optical anemometry.

15776. Manning, J. R., Stark, J. P., **Complete-path matrix equations for tracer diffusion coefficients and correlation factors,** *Phys. Rev. B* **12,** No. 6, 2075-2079 (Sept. 15, 1975).

Key words: atom migration; correlation factor; crystal defect; diffusion coefficient; matrix equations; nonrandom walk equation.

General complete-path matrix equations are derived for the tracer diffusion coefficient and correlation factor by taking into account the frequency with which defects encounter a tracer atom and the possibility of multiple exchanges of a defect with the atom. These equations apply even when mirror symmetry and rotational symmetry of the crystal and defect are lacking, as for example when diffusion occurs via complex defects in noncubic crystals. They also are valid for diffusion along any diffusion direction and where the individual atom jumps provide a variety of jump distances. It is shown that the general equations reduce to those of Stark and of Howard in the special case where there is mirror symmetry across the diffusion place.

15777. Fraker, A. C., **Microstructures of Ti-1.5 w/o Ni alloys with Mo and Al additions,** (Proc. 33d Annual Electron Microscopy Society of America, Las Vegas, NV, Aug. 11-15, 1975), Paper in *Proceedings Electron Microscopy Society of America, 33d Annual Meeting,* G. W. Bailey, Ed., pp. 54-55 (Claitor's Publ. Div., Baton Rouge, LA, 1975).

Key words: microstructures; titanium; transmission electron microscopy.

Small additions of Mo to Ti-0.8 to 1 w/o Ni alloys produce good crevice corrosion resistance and improved fabrication properties. This work shows how the Ti-1.5 w/o Ni alloy microstructure is altered by adding 2 w/o Mo or 2 w/o Al. It was concluded that the Mo addition produces a more elongated microstructure with smaller sized Ti_2Ni precipitates, enhances the martensitic reaction and increases the hardness of the material. The Al addition does not change the microstructure markedly but does cause an increase in microhardness.

15778. Ruff, A. W., Ives, L. K., **Measurement of solid particle velocity in erosive wear,** *Wear Short Commun.* **35,** 195-199 (1975).

Key words: erosive wear; particle impingement; particle velocity measurement; wear; wear testing.

A method is described for determining the velocity of solid particles in a gas-particulate stream applied to erosion testing of materials. A simple mechanical configuration allows the measurement to be made under a wide range of equipment conditions. The time-of-flight of the particles is determined over a controlled path length between two rotating disks. Examples of measurements on several test apparatus are presented. The importance of nozzle design is discussed. A comparison between particle and gas stream velocity is presented.

15779. Kuriyama, M., **A classical derivation of the dynamical diffraction equation for imperfect crystals based on the Ewald-Laue-Bethe theory,** *Acta Crystallogr.* **A31,** Part 6, 774-779 (Nov. 1975).

Key words: dynamical diffraction equation; imperfect crystals; scattering matrix theory.

The basic equation of dynamical diffraction for imperfect crystals, which has been derived previously by a general dynamical theory of diffraction, is rederived classically based on the Ewald-Laue-Bethe concept, thus completing the formulation of a "scattering matrix" theory. It is shown in this classical derivation that a series of assumptions is required at each stage of the mathematical formulation to allow it to proceed further. These assumptions are then viewed in terms of the general dynamical theory of diffraction, and found unnecessary in the rigorous formulation. This classical formulation provides a conceptual relation between the traditional Ewald-Laue-Bethe dynamical theory and the general dynamical theory, one that has been derived with the aid of quantum-field theory.

15780. McAlister, A. J., Cuthill, J. R., Dobbyn, R. C., Williams, M. L., Watson, R. E., **Band structure of face-centered and body-centered-cubic 3*d* transition metals,** *Phys. Rev. B* **12,** No. 8, 2973-2983 (Oct. 15, 1975).

Key words: Co; Cr; *d*-band widths; electronic structure; Fe; ferromagnetism; soft x-ray emission; soft x-ray spectra; transition metals.

Measurements of the soft-x-ray $M_{2,3}$ emission spectra of face-centered Fe and Co, and body-centered Fe, Cr, and V are reported and M_3 single-hole excitation profiles are estimated. 3*d* bandwidths inferred from these results and earlier data on Cu and Ni are compared with band-theory predictions. As has been seen previously with x-ray and ultraviolet photoemission, the experimental Ni bandwidth is markedly narrower than theory predicts; there is a suggestion that the bandwidth of Cu is somewhat broader; theory and the present results are in fair agreement for the other metals. Fine structure is seen in the spectra; correlations are noted in the weak structure of metals of common crystal structure; and structural correlations with x-ray and ultraviolet photoemission data are seen as well.

15781. Sawyer, D. E., Berning, D. W., **Laser scanning of active semiconductor devices,** *Proc. Technical Digest, International Electron Devices Meeting, Washington, DC, Dec. 1-3, 1975, IEDM Technical Digest,* pp. 111-114 (1975).

Key words: active devices; hot spots; laser scanning; logic flow observation; LSI testing; nondestructive test; nonlinearity measurement; UHF transistor measurement.

A laser scanner is described which can nondestructively explore electrical characteristics of semiconductor devices on a point-by-point basis. The results of applying the scanner to electronically map temperature distributions and hot spots in a power transistor are given. The results of mapping localized nonlinearities in electrical operation and 0.5 GHz response are also presented. Pictures show the progress of logic in a MOS shift register and demonstrate the ability to change at will the logical state of an embedded active cell with the laser.

15782. Mathey, R. G., Clifton, J. R., **Bond of coated reinforcing bars in concrete,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST1, 215-229 (Jan. 1976).

Key words: bond strength; coated reinforcing bars; evaluation; organic coatings; pullout tests.

The bond strengths were determined for 23 epoxy-coated (10 different epoxy coatings), six polyvinyl chloride-coated (three different coating materials), and five uncoated reinforcing bars. The length of embedment of the reinforcing bar in the concrete was 12 in (305 mm). The loads or bond stresses corresponding to a loaded-end slip of 0.01 in (0.25 mm) or a free-end slip of 0.002 in (0.051 mm) were considered as critical values in determining the bond strength, depending on which of these values of slip developed first. For coating film thicknesses ranging from 0.001 in to 0.011 in, the epoxy-coated bars developed bond strengths essentially equal to the bond strengths for uncoated bars. Experimental values were higher than minimum acceptable values in building code and highway bridge requirements. Bond strengths of the polyvinyl chloride-coated bars and bars with thick epoxy coatings were unacceptable.

15783. Harrison, S. H., **Neutron activation analysis: A useful tool for evaluating water sampling and analysis techniques,** *Proc. Transactions American Nuclear Society, New Orleans, LA, June 6-13, 1975,* **21,** 110-111 (1975).

Key words: neutron activation analysis; particulates; sampling; species; trace element concentrations.

Neutron activation analysis (NAA) was used to determine the natural variability of trace element concentrations at a single sampling location over a short time (2 or 3 hours) and to compare the performance of two different water sampling devices. Data for both dissolved species and suspended particulates are presented. A normalizing technique for evaluating suspended particulate data is described.

Unique results obtained with this normalizing technique are demonstrated on data from a highly polluted tributary of the Chesapeake Bay.

15784. McClintock, W., Henry, R. C., Moos, H. W., Linsky, J. L., **Ultraviolet observations of cool stars. IV. Intensities of Lyman-α and Mg II in Epsilon Pegasi and Epsilon Eridani, and line width-luminosity correlations,** *Astrophys. J.* **202,** No. 3, 733-740 (Dec. 15, 1975).

Key words: chromospheres, stellar; *Copernicus* observations; ultraviolet stellar spectra; Wilson-Bappu effect.

The Princeton spectrometer on the *Copernicus* satellite has been used to confirm the existence of a line width-luminosity relation for the Lα and Mg II λ2800 chromospheric emission lines in K-type stars, by observation of a K2 dwarf (ϵ Eri) and of a K2 supergiant (ϵ Peg). Combined with previously reported observations of lines in three K giants (α Boo, α Tau, and β Gem), the data are consistent with an identical dependence of linewidth on absolute visual magnitude for the Ca II K, Lα, and Mg II λ2795 lines. Surface fluxes of Lα, Mg II λ2800, and O V λ1218 (upper limit) for ϵ Eri, and of Mg II λ2800 for ϵ Peg are also compared with values reported previously for the three giant stars.

15785. Unassigned.

15786. Galloway, K. F., Keery, W. J., Leedy, K. O., **Integrated circuit damage resulting from SEM examination,** *Proc. 25th Annual Electronic Components Conf., Washington, DC, May 12-14, 1975*, pp. 263-266 (Institute of Electrical and Electronics Engineers, New York, NY, 1975).

Key words: electron beam damage; electron beam energy deposition; integrated circuits; ionizing radiation effects; scanning electron microscope; surface effects.

The scanning electron microscope utilizes a well controlled low-energy electron beam which is a potential source of damage to specimens under investigation. In particular, the energy deposited by the electron beam can alter the surface oxide properties of semiconductor devices which can, in turn, lead to a change in device electrical parameters. The energy deposition and the resulting oxide changes are reviewed in this paper, and the effects of the scanning electron beam are illustrated.

15787. Heinrich, K. F. J., **Scanning electron probe microanalysis,** Chapter in *Advances in Optical and Electron Microscopy* **6,** 275-301 (Academic Press, Inc., London, England, 1975).

Key words: color composite technique; counting statistics; electron beam scanning; electron probe microanalysis; x-ray analysis.

Scanning electron probe microanalysis is related to microscopy as well as to chemical analysis. The present techniques can be considered as incomplete variations of a hypothetical model of quantitative elemental characterization of a microscopic area. Such a "complete scanning analysis" is at present limited by statistics of achievable count rates, and by the requirements for applying complicated transformations or "corrections" to the experimental results. The use of color composites and of data collection and evaluation systems which are becoming more readily available provides improved techniques for the presentation of information. Further progress depends upon the development of x-ray detectors having low coincidence losses and of extensive storage and manipulation of digital information.

15788. Freund, S. M., Hougen, J. T., Lafferty, W. J., **Laser magnetic resonance spectra of $^{14}NO_2$ and $^{15}NO_2$ near 1600 cm^{-1},** *Can. J. Phys.* **53,** No. 19, 1929-1938 (1975).

Key words: band center; intensities; laser magnetic resonance; nitrogen dioxide; rotational assignment; spin-rotation splittings.

Two laser magnetic resonance patterns for $^{14}NO_2$ and six patterns for $^{15}NO_2$, observed using six CO laser transitions, have been analyzed to yield spin corrected zero-field vibration–rotation transition wave numbers and zero-field spin–rotation splittings. The $^{14}NO_2$ results are in good agreement with results obtained from conventional infrared grating studies. The $^{15}NO_2$ results allow new values of $\nu_0 = 1582.107 \pm 0.008$, $A' - A'' = -0.2116 \pm 0.0011$, and $D_K' - D_K'' = -1.39 \pm 0.20 \times 10^{-4}$ cm^{-1} to be determined for the ν_3 fundamental of that molecule (errors are 3 standard deviations). Two spectral figures and a list of assigned Zeeman lines are presented to permit using this stable molecule as an aid in adjusting newly constructed instruments. Closed form approximate intensity expressions are given for Zeeman transitions of the type observed in this work, i.e., for sharp partially spin forbidden Zeeman transitions in A type bands of near prolate asymmetric rotors.

15789. Carpenter, B. S., Myklebust, R. L., **Comparative analysis for boron in steel by ion microprobe mass analyzer and the nuclear track technique,** *Anal. Chim. Acta Short Commun.* **81,** 409-411 (1976).

Key words: alpha particles; boron; ion microprobe mass analyzer; nuclear track technique; standard reference material; steel.

This work describes the analytical capabilities of the NBS Ion Microprobe Mass Analyzer for determining trace concentrations of boron in a steel matrix. In addition, the boron concentration values obtained in this way are compared with those obtained by the Nuclear Track Technique, in which the boron concentration and distribution are determined by counting the alpha tracks produced by the nuclear reaction $^{10}B(n, \alpha)^7Li$ in plastic solid-state recorders. Both methods are surface, or limited depth, microtechniques that perform analyses through interaction with individual atoms; thus, comparison of the results from both methods is useful in revealing the spatial homogeneity of the boron in the steels.

15790. Newman, M., **Some results on symplectic matrices,** *Linear and Multilinear Algebra* **3,** 95-98 (1975).

Key words: generalized permutations; pth roots; symplectic matrices.

The principal results are that if A is an integral matrix such that AA^T is symplectic then $A = CQ$, where Q is a permutation matrix and C is symplectic; and that if A is a hermitian positive definite matrix which is symplectic, and B is the unique hermitian positive definite pth root of A, where p is a positive integer, then B is also symplectic.

15791. Carlsten, J. L., Peterson, J. R., Lineberger, W. C., **Binding of an electron by the field of a molecular dipole—LiCl$^-$,** *Chem. Phys. Lett.* **37,** No. 1, 5-8 (Jan. 1, 1976).

Key words: alkali-halide; negative ions; photoelectron spectroscopy; polar molecules.

We present direct experimental evidence for the binding of an electron by the dipole moment of a neutral molecule. The photoelectron spectrum of LiCl$^-$ was obtained and analyzed to determine that the binding energy of the electron in the LiCl$^-$ ion is (0.61 ± 0.02) eV. This result is an order of magnitude smaller than the predictions of the fixed dipole theoretical model, but is consistent with a recent calculation, which allows for distortion of the dipolar core.

15792. Kilmer, R. D., Leasure, W. A., Jr., Mathews, D. E., **Truck Noise I-C: Pavement surface effects on the generation of truck tire noise,** *Report No. DOT-TST-76-49*, 111 pages (Available from the National Technical Information Service, Springfield, VA 22161, Oct. 1975).

Key words: acoustics; noise measurement; noise (sound); tire noise; transportation noise; truck.

This report presents data showing the effect that pavement surface has on the generation of truck tire noise. Three different tread designs–rib, cross-bar and pocket–were tested at speeds of 40, 50 and 60 mph (64.4, 80.5 and 96.5 km/hr) while coasting on eight different pavement surfaces at the Texas Transportation Institute. These surfaces represent a wide range of surface texture. Also presented are the results of one method of quantitatively characterizing pavement surface texture; namely, the mean square value of the macrotexture profile, obtained utilizing a macrotexture profile tracer. Plots of tire noise versus this particular measure of surface texture show that up to a certain macrotexture the generated noise is tire dependent while above this value the pavement macrotexture appears to be the controlling parameter. Because of the wide variation in noise level with changes in surface texture for the pocket retread, this tire is investigated as a possible simple calibrator of surface texture.

These investigations serve as the basis for evaluation of the effect of surface texture on the generation of tire noise.

15793. Lofquist, K. E. B., **An effect of permeability on sand transport by waves,** *Technical Memorandum No. 62,* 74 pages (U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA, Dec. 1975). (Available from the National Technical Information Service, Springfield, VA 22161).

Key words: beach accretion; coastal processes; offshore zone; oscillatory water tunnel; permeability effect on sand transport; ripples, sand; sand motion under waves.

Permeability effects on the movement of sand in oscillatory flows are observed in laboratory experiments which approximate prototype conditions at the seabed under progressive waves. A natural sand is used, wave periods range between three and fourteen seconds, and the sand surfaces are naturally rippled. The apparatus has a symmetry which removes all effects, except those of permeability, which might cause a net movement of the sand. Onshore and offshore directions are determined by the phase relationships between the horizontal flows and superposed vertical permeability flows. A positive permeability effect is found, in that the ripple profiles move in the onshore direction. The velocity of this motion is measured and described in a simple dimensionless plot. The associated net transport of sand is not observed directly, but can be inferred, to an extent, from the motions of the ripple profiles. The effects of permeability are cumulative and can be significant in coastal processes of long duration. Any estimate of the local rate of sand transport onshore due to permeability involves the distribution of permeabilities within the seabed which are largely unknown. An overall estimate is less than 1 cubic meter per meter of shoreline per year, which is negligible for most engineering considerations.

15794. Bender, P. L., Silverberg, E. C., **Present tectonic-plate motions from lunar ranging,** *Tectonophysics* **29,** 1-7 (1975).

Key words: geodesy; geodynamics; lasers; metrology; moon; tectonics.

Measurements to determine the motion of the Pacific Plate with respect to North America are planned to start within a few months. The University of Hawaii Lunar Ranging Station on Maui is expected to begin operating, and to achieve an accuracy of 2 or 3 cm soon for a single run. The University of Texas McDonald Observatory has been achieving an accuracy of 8-15 cm on a routine basis since late 1971. Work on further improving the McDonald accuracy is planned. Using data from many runs, an accuracy of 1 cm/yr is expected for the relative motion within the first few years.

A transportable lunar-ranging station has been proposed which could be constructed in about eighteen months. The station could observe for 3-6 weeks at a chosen site, and determine the location of the site with respect to the fixed lunar-ranging stations. The accuracy expected is 1-3 cm in each coordinate. If approved, a possible initial itinerary for the station might be as follows: (a) two or three sites in California, including Goldstone, plus one site in Utah; (b) sites in Baja California and Mexico, plus several others in the U.S.; (c) several sites in Central America, the Caribbean, and South America; (d) repeat measurements in California, Utah, and Baja California, plus initial measurements at sites in Africa, India, and the Pacific. It is expected that data on plate motions also will become available from satellite range measurements and VLBI.

15795. Madden, R. P., **Atomic physics with synchrotron radiation,** (Proc. IX Int. Conf. on The Physics of Electronic and Atomic Collisions, Seattle, WA, July 24-30, 1975), Paper in *The Physics of Electronic and Atomic Collisions,* J. S. Risley and R. Geballe, Eds., pp. 563-583 (University Washington Press, Seattle, WA, 1976).

Key words: atomic physics; synchrotron radiation; vacuum ultraviolet.

The availability of synchrotron radiation sources is increasing steadily and their application to problems in atomic physics is growing rapidly. This paper reviews the work in absorption spectroscopy, photoelectron spectroscopy, fluorescence, mass spectroscopy lifetime measurements and time resolved spectra which is currently being done with this powerful source of polarized continuum radiation.

15796. Berger, H., **Detection systems for neutron radiography,** (Proc. American Society for Testing and Materials Symp. on Neutron Radiography and Gaging, Gaithersburg, MD, Feb. 10, 1975), Paper in *Practical Applications of Neutron Radiography and Gaging, Am. Soc. Test. Mater. Spec. Tech. Publ. 586,* pp. 35-57 (Jan. 1976).

Key words: films; images; neutron radiography; nondestructive tests; real-time imaging; thermoluminescence; track-etch.

Image detection methods for neutron radiography are described and capabilities of the methods in terms of exposure requirements, spatial resolution, and contrast are given. Neutron energy ranges cold, thermal, epithermal, and fast are included, but emphasis is on detectors for thermal neutron images. Image methods include photographic film, real-time, track-etch, gas-cell, and thermoluminescent; major emphasis is on film techniques, both direct exposure and transfer.

15797. Burns, G. W., Hurst, W. S., **Highly stable, sheathed, beryllia insulated, tungsten-rhenium alloy thermocouples,** (Proc. Int. Colloquium on High-Temperature In-Pile Thermometry, JRC Petten, Netherlands, Dec. 12-13, 1974), Paper in *International Colloquium on High-Temperature In-Pile Thermometry,* P. von der Hardt, P. Zeisser, and F. Mason, Eds., EUR 5395 **1,** 1-23 (Commission of the European Communities Directorate-General Scientific and Technical Information and Information Management, Luxembourg, Belgium, 1975).

Key words: beryllium oxide; refractory metals; sheathed thermocouples; tantalum; temperature measurements; thermal emf drift; tungsten-rhenium alloys.

The fabrication and performance testing of 1.6 mm diameter tantalum sheathed, beryllium oxide (BeO) insulated, W-3% Re/W-25% Re thermocouples are reported. Fully assembled thermocouples constructed from aged thermoelements, specially heat treated, sintered BeO insulators, and specially cleaned and etched tantalum sheaths were tested for 2059 h at 1800 °C in a helium environment. The measured thermal emf drifts were less than the equivalent of 1 °C per thousand hours of exposure at 1800 °C. No gross chemical attack or degradation of the component materials was evident. The fabrication techniques, thermal emf test results, and post-test analyses of the component materials are discussed.

15798. Reader, J., **Energy levels of singly ionized cesium (Cs II),** *Phys. Rev. A* **13,** No. 2, 507-516 (Feb. 1976).

Key words: cesium; energy levels; spectra.

The system of observed energy levels of Cs II of Wheatley and Sawyer has been reinterpreted through the use of Hartree-Fock calculations and published Zeeman effect and hyperfine-structure measurements. Of the 80 known levels, 30 have been rejected as being not real. A revised list of 54 observed levels of Cs II is presented that includes the $5p\,^5 5d\,^1P_1$ level recently found by

Reader and Epstein and three levels of the $5p\,^5 6d$ configuration that were located with the aid of Sommer's line list. Percentage compositions and Slater parameters are given for the $5p\,^5(5d+6s)$, $6p$, and $(6d+7s)$ configurations. Severe configuration mixing is found for levels of the $5p\,^5(5d+6s)$ group. The measured g values of the $5p^5(5d+6s)$ levels provide evidence of a strong term dependence for the parameter $G^1(5p5d)$. By taking into account displacements of the $5p^5ns$ levels due to configuration interaction, the ionization energy is revised to be $186\,600 \pm 150$ cm^{-1} (23.14 ± 0.02 eV).

15799. Bender, P. L., **Applications of PTTI to new techniques for determining crustal movements, polar motion, and the rotation of the earth,** *Proc. 6th Annual Precise Time and Time Interval (PTTI) Planning Meeting, Washington, DC, Dec. 3-5, 1974,* pp. 39-55 (U.S. Naval Research Laboratory, Washington, DC, Dec. 1975).

Key words: crustal moments; earth rotation; geodynamics; lunar distance; microwave interferometry; plate tectonics; satellite geodesy.

New extra-terrestrial techniques for geodesy and geodynamics include laser range measurements to the moon or to artificial satellites, Doppler measurements with the Transit satellite system, and both independent-clock and linked-antenna microwave interferometry. The ways in which PTTI measurements are used in these techniques will be reviewed, and the accuracies expected during the latter half of the 1970's will be discussed. At least 3 of the techniques appear capable of giving accuracies of 5 cm or better in each coordinate for many points on the Earth's surface, and comparable accuracies for the Earth's rotation and polar motion. For fixed stations or for sites a few hundred km apart, baseline lengths accurate to 1 cm may be achieved. Ways in which the complementary aspects of the different techniques can be exploited will be discussed, as well as how they tie in with improved ground techniques for determining crustal movements. Some recent results from the extra-terrestrial methods will be mentioned.

15800. Hoer, C. A., Engen, G. F., **Analysis of a six-port junction for measuring** v, i, a, b, z, Γ**, and phase,** (Proc. 6th Conf. of the Int. Measurement Confederation, Dresden, Germany, June 17-23, 1973), Paper in *Measurement and Instrumentation, Acta IMEKO 1973,* **1,** 213-222 (Publishing House of the Hungarian Academy of Sciences, Akadémiai Kiadó, Budapest, Hungary, 1973).

Key words: admittance; current; impedance; phase angles; power; reflection coefficient; six-port; voltage.

This theoretical paper shows how complex voltage, current, incident and emergent wave amplitudes, immittance, reflection coefficients, and phase angles can all be measured with an arbitrary six-port junction. Four ports are terminated with power meters or other detectors from which power values can be obtained.

In particular, if v represents voltage, $|v|^2$ is given as a linear function of the four power meter indications. The same is true for current and the wave amplitudes. Complex immittance, or reflection coefficient, on the other hand, is given by the ratio between two linear combinations of the power meter readings.

Some practical design considerations are also given.

15801. Bender, P. L., **Reference coordinate system requirements for geophysics,** (Proc. IAU Symposium No. 26 on Reference Coordinate Systems for Earth Dynamics, Torun, Poland, Aug. 26-31, 1974), Paper in *Reference Coordinate Systems for Earth Dynamics,* B. Kolaczek and G. Weiffenbach, Eds., pp. 85-92 (Polish Academy of Sciences, Warsaw, Poland, Apr. 1975).

Key words: coordinate systems; geodesy; geodynamics; lasers; tectonics; VLBI.

Five important geodynamical quantities which are closely linked are: (1) motions of points on the Earth's surface; (2) polar motion; (3) changes in UT1-UTC; (4) nutation; and (5) motion of the geocenter. For each of these we expect to achieve measurements in the near future which have an accuracy of 1 to 3 cm or 0.3 to 1 milliarcsec.

From a metrological point of view, one can say simply: "Measure each quantity against whichever coordinate system you can make the most accurate measurements with respect to." I believe that this statement should serve as a guiding principle for the recommendations of the colloquium. However, it also is important that the coordinate systems help to provide a clear separation between the different phenomena of interest, and correspond closely to the conceptual definitions in terms of which geophysicists think about the phenomena.

In any discussion of angular motion in space, both a "body-fixed" system and a "space-fixed" system are used. Some relevant types of coordinate systems, reference directions, or reference points which have been considered are: (1) celestial systems based on optical star catalogs, distant galaxies, radio source catalogs, or the Moon and inner planets; (2) the Earth's axis rotation, which defines a line through the Earth as well as a celestial reference direction; (3) the geocenter; and (4) "quasi-Earth-fixed" coordinate systems.

When a geophysicist discusses UT1 and polar motion, he usually is thinking of the angular motion of the main part of the mantle with respect to an inertial frame and to the direction of the spin axis. Since the velocities of relative motion in most of the mantle are expected to be extremely small, even if "substantial" deep convection is occurring, the conceptual "quasi-Earth-fixed" reference frame seems well defined. Methods for realizing a close approximation to this frame fortunately exist. Hopefully, this colloquium will recommend procedures for establishing and maintaining such a system for use in geodynamics. Motion of points on the Earth's surface and of the geocenter can be measured against such a system with the full accuracy of the new techniques.

The situation with respect to celestial reference frames is different. The various measurement techniques give changes in the orientation of the Earth relative to different systems, so that we would like to know the relative motions of the systems in order to compare the results. However, there does not appear to be a need for defining any new system. Subjective figures of merit for the various systems depend on both the accuracy with which measurements can be made against them and the degree to which they can be related to inertial systems.

The main coordinate system requirement related to the 5 geodynamic quantities discussed in this talk is thus for the establishment and maintenance of a "quasi-Earth-fixed" coordinate system which closely approximates the motion of the main part of the mantle. Changes in the orientation of this system with respect to the various celestial systems can be determined by both the new and the conventional techniques, provided that some knowledge of changes in the local vertical is available. Changes in the axis of rotation and in the geocenter with respect to this system also can be obtained, as well as measurements of nutation.

15802. Clough, R. B., **A note on the measurement of proportional limit under multiaxial stresses,** *J. Test. Eval.* **4,** No. 2, 139-140 (1976).

Key words: flow surface; multiaxial stresses; plasticity; proportional limit.

Theoretical definitions of the multiaxial plastic flow surface are exact; however, ambiguities arise in the experimental measurement. A new method for measuring the multiaxial flow surface based on maximum elastic stress rate is proposed which eliminates these ambiguities. It is applied to biaxial yielding.

15803. Bowman, R. R., **A probe for measuring temperature in radio-frequency-heated material,** *IEEE Trans. Microwave Theory Tech. Short Papers* **MTT-24,** No. 1, 43-45 (Jan. 1976).

Key words: high-resistance leads; radio frequency heating; temperature measurements; thermistor probe.

Measuring temperature in material being heated by radio-frequency (RF) fields is difficult because of field perturbations and direct heating caused by any conventional leads connected to the temperature sensor. A temperature probe consisting simply of a thermistor and plastic high-resistance leads appears to practically eliminate these problems. The design goals are described, and the performance of an initial test model of this type of probe is discussed.

15804. Yaghjian, A. D., **Direct integration of the field equations for electroacoustic transducers,** *Proc. IEEE Letters* **62,** No. 6, 858-859 (June 1974).

Key words: electroacoustic; integration; transducer.

Expressions are derived for the electroacoustic fields inside a linear transducer in terms of the volume sources and the fields on the surface of the transducer.

15805. Straty, G. C., Tsumura, R., **Phase transition and melting pressures of solid ethane,** *J. Chem. Phys.* **64,** No. 2, 859-861 (Jan. 15, 1976).

Key words: ethane; melting line; melting pressures; solid ethane; solid phase transition.

The melting pressures of ethane at 14 temperatures from near the triple point to 95.50 K and pressures to 32.0 MPa are reported. A triple point temperature of 90.348 ± 0.005 K is obtained from the data which is in agreement with the determination of Clusius and Weigand (1940) but in substantial disagreement with other determinations. Qualitative evidence has been obtained which indicates the existence of a previously unrecognized solid phase transition along a boundary roughly parallel to the melting line at a temperature about 0.5 K below the melting temperature, suggesting that some previous melting point determinations may have been influenced by misinterpretation of the effects of this transition.

15806. Bender, P. L., **Prospects for rapid realization of a quasi-Earth-fixed coordinate system,** (Proc. IAU Symposium No. 26 on Reference Coordinate Systems for Earth Dynamics, Torun, Poland, Aug. 26-31, 1974), Paper in *Reference Coordinate Systems for Earth Dynamics*, B. Kolaczek and G. Weiffenbach, Eds., pp. 297-302 (Polish Academy of Sciences, Warsaw, Poland, Apr. 1975).

Key words: coordinate systems; geodesy; geodynamics; lasers; tectonics; VLBI.

It appears that a combination of VLBI, lunar ranging, and satellite ranging can provide a quasi-Earth-fixed coordinate system with high accuracy and good coverage more rapidly than any one technique alone. In considering this possibility, the conceptual separation of the job into two parts seems useful. There are: (1) establishment of a global network of at least three fundamental reference points on major plates, and (2) the determination of a larger number of regional reference points of geodynamic interest. The example of lunar ranging plus satellite ranging is used to illustrate one way in which an accurate realization of an initial terrestrial system could be achieved quickly.

15807. Hutchinson, J. M. R., Lucas, L. L., Mullen, P. A., **Study of the scattering correction for thick uranium-oxide and other α-particle sources—II: Experimental,** *Int. J. Appl. Radiat. Isot.* **27,** No. 1, 43-45 (Jan. 1976).

Key words: alpha particles; backscattering; gadolinium-148; polonium-210; self absorption; uranium-oxide.

Experimental values of the 2π α-particle counting rate, $C_{2\pi}$, including scattering, divided by the disintegration rate, N_0, are reported for uranium dioxide, ^{210}Po and ^{148}Gd sources mounted on platinum backings, and a ^{210}Po source on a U_3O_8 backing. The $^{235}UO_2$ source thicknesses varied from 0.05 to 1.1 mg/cm^2. The experimental values of the scattering are in agreement with theoretical values given in Part I (this issue), which take into account source thickness, α-particle energy, and composition of the backing material.

15808. Lucas, L. L., Hutchinson, J. M. R., **Study of the scattering correction for thick uranium-oxide and other α-particle sources—I: Theoretical,** *Int. J. Appl. Radiat. Isot.* **27,** No. 1, 35-42 (Jan. 1976).

Key words: alpha particles; backscattering; disintegration rate; ranges; self-absorption; uranium oxide.

Theoretical values of the 2π α-particle counting rate, $C_{2\pi}$, including scattering, divided by the disintegration rate, N_0, are calculated for α-particle sources mounted on flat backing materials. The theoretical values (Part I) and experimental values (Part II) are in good agreement, and show that: (a) $C_{2\pi}/N_0$ values as a function of α-particle energy and source thickness can be calculated on the basis of a simple physical model; (b) The scattering correction, expressed as a fraction of the disintegration rate, decreases with increasing source thickness; and (c) The α-particle scattering in uranium-oxide is much less than the scattering in platinum, in disagreement with previous estimates. The calculations are readily extended to other source compositions and α-particle energies.

15809. Jones, M. C., Peterson, R. G., **A study of flow stability in helium cooling systems,** *J. Heat Transfer* **97,** No. 4, 521-527 (Nov. 1975).

Key words: computations; cooling system; cryogenics; electric power transmission; flow stability; helium; oscillations; superconductors; theory.

Methods have been developed for the computation of the frequency response and stability of helium cooling systems in the frequency range of the density wave instability. While more generally applicable, these methods were developed for a study of superconducting power transmission. Special features are the use of helium thermodynamic properties derived at every point from the exact equation of state, and the full accounting of the effect of compressibility. Classical linear control theory is employed throughout. By using a finite difference approach to the integration of the conservation equations over the space coordinate, the accuracy obtainable is limited only by the computation time available. Examples are given for representative transmission line parameters with the helium at a variety of supercritical pressures. It is concluded that, while density wave instability

is a real potential problem in superconducting power transmission lines, it is not difficult to select operating parameters in a safe stable regime.

15810. Marshall, H. E., Ruegg, R. T., **Cost sharing to induce efficient techniques of abating wastewater pollution,** *J. Environ. Econ. Manage.* **2,** 107-119 (1975).

Key words: cost sharing; efficiency; environment; financing; grants; pollution abatement; wastewater; water pollution; water resources.

This paper analyzes existing cost-sharing rules for wastewater pollution grants administered by the Environmental Protection Agency under the 1972 Amendments to the Federal Water Pollution Control Act. It identifies and measures biases in the existing cost-sharing rules that encourage nonfederal interests to select particular techniques (e.g., capital-intensive techniques) over others even when the selected techniques are not the least costly to the nation. The paper develops theoretically a cost-sharing condition—that the same percentage cost share be applied to all abatement techniques—that would eliminate the cost-sharing bias. Alternative cost-sharing approaches are evaluated in terms of their biasing effects and their absolute dollar costs for federal and nonfederal project participants.

15811. Lias, S. G., Eyler, J. R., Ausloos, P., **Hydride transfer reactions involving saturated hydrocarbons and CCl_3^+, CCl_2H^+, CCl_2F^+, CF_2Cl^+, CF_2H^+, CF_3^+, NO^+, $C_2H_5^+$, sec-$C_3H_7^+$ and t-$C_4H_9^+$,** *Int. J. Mass Spectrom. Ion Phys.* **19,** 219-239 (1976).

Key words: collision processes; halocarbon ions; hydrocarbons; ion-molecule reactions; kinetics; rate constants.

The compounds CCl_4, CCl_3H, CCl_3F, CCl_2F_2, CF_3H, CF_4, NO, C_2H_6, neo-C_5H_{12}, and C_3H_8 were ionized by low energy electrons in a pulsed ion cyclotron resonance spectrometer to produce CCl_3^+, CCl_2H^+, CCl_2F^+, CF_2Cl^+, CF_2H^+, CF_3^+, NO^+, $C_2H_5^+$, t-$C_4H_9^+$, and sec-$C_3H_7^+$ ions, respectively. In these pure compounds, the respective ions formed are all unreactive, and can be trapped with essentially no loss in the ICR analyzer cell for up to 0.2 s after their formation, at a pressure of $10^{-7}-10^{-5}$ torr. When alkanes or cycloalkanes are added to these compounds, the predominant ions formed in each case undergo a hydride transfer reaction with the added alkane. This is the only reaction channel:

$$A^+ + RH \rightarrow AH + R^+$$

(where A^+ is the initial ion formed and RH is the added alkane or cycloalkane). By following the abundances of the reactant ions as a function of time in these dilute mixtures, approximately one hundred rate coefficients of hydride transfer reactions of thermal ions (in the range $10^{-12}-10^{-9}$ cm^3 molecule^{-1} s^{-1}) have been determined. For several of these ions, it is demonstrated that even when reaction is very exothermic at every site in the molecule the reacting ion exhibits positional selectivity. Detailed examination of the reaction probabilities for these ions reacting with alkanes of different chain lengths and structures leads to the conclusion that the rates of hydride transfer reactions depend in part on the exothermicity of the reaction and in part on the lifetime of the ion-molecule complex. For large reactant ions such as t-$C_4H_9^+$, steric effects may also play a role. The product ions formed in these hydride transfer reactions undergo further fragmentation to an extent which depends on the exothermicity of the reaction; the most important fragmentation paths correspond to loss of C_2-C_4 olefins from the product alkyl ions.

15812. Powell, C. J., **Cross sections for ionization of inner-shell electrons by electrons,** *Rev. Mod. Phys.* **48,** No. 1, 33-47 (Jan. 1, 1976).

Key words: Bethe theory; cross sections; electron; inner-shell electrons; ionization; *K*-shell; *L*-shell; photoabsorption.

A survey is given of the available cross-section data for ionization of inner-shell electrons by incident electrons in the range of interest for electron-probe microanalysis and for Auger-electron spectroscopy of solid surfaces. Owing to the paucity of data, the bulk of the discussion is limited to *K*-shell and *L*-shell ionization of light atoms. Calculated, semiempirical, and experimental cross-section data have been intercompared graphically and through fits to the linearized Bethe equation for inner-shell ionization (the Fano plot). Almost all of the data could be satisfactorily fitted over the range $4 \lesssim U_{nl} \lesssim 30$, where $U_{nl} = E_0/E_{nl}$, E_0 is the incident electron energy, and E_{nl} the binding energy of electrons in the *nl* shell. From these fits, values could be obtained of the "effective" Bethe parameters b_{nl} and c_{nl}. Values of the parameter b_{nl} have also been derived from photoabsorption data and were found to be generally consistent with the ionization data if account was taken of the distribution of differential oscillator strength with respect to excitation energy and the consequent expected variation of b_{nl} with incident electron energy. The derived "effective" Bethe parameters should not therefore be used outside the range of each fit.

15813. Waclawski, B. J., Herbst, J. F., **Photoemission for Xe physisorbed on W(100): Evidence for surface crystal-field effects,** *Phys. Rev. Lett.* **35,** No. 23, 1594-1596 (Dec. 8, 1975).

Key words: crystal field; photoemission; physisorption; tungsten (100); xenon.

Photoemission spectra at $h\nu = 21.2$ eV reveal two $5p$ levels for xenon physisorbed on a tungsten (100) surface. The spin-orbit splitting of the two levels and their intensity ratio correspond closely to gas-phase measurements, while the $5p_{3/2}$ peak is significantly broadened with respect to the $5p_{1/2}$. We interpret the broadened structure as an unresolved doublet resulting from splitting the Xe $5p_{3/2}$ states in the tungsten-surface crystal field.

15814. Fuggle, J. C., Madey, T. E., Steinkilberg, M., Menzel, D., **Photoelectron spectroscopic studies of adsorption of CO and oxygen on Ru(001),** *Surf. Sci.* **52,** 521-541 (1975).

Key words: adsorbate; chemisorption; ruthenium; ultraviolet photoelectron spectroscopy; x-ray photoelectron spectroscopy.

XPS and UPS have been used for a detailed study of the adsorption and coadsorption of CO and oxygen on a clean Ru(001) single crystal. The measured substrate and adsorbate core level binding energies and valence levels are discussed. The O 1s XPS peak intensity has been used for kinetic studies of adsorption and coadsorption. Some studies of the angular dependence of adsorbate and substrate peak intensity ratios are presented. We also present data on the shifts of XPS peaks and changes in UPS spectra as a function of adsorbate coverage. The data are correlated with the results of earlier measurements with other methods.

15815. Bardsley, J. N., Junker, B. R., Norcross, D. W., **Pseudopotential calculations for Na_2^+, Na and Na_2^-,** *Chem. Phys. Lett.* **37,** No. 3, 502-506 (Feb. 1, 1976).

Key words: molecular structure; pseudopotentials.

Potential curves have been computed for five states of Na_2^+, five states of Na_2 and two states of Na_2^- using a pseudopotential approach. The results are consistent with the accepted attribution to a $^3\Pi$ state of the perturbations observed in transitions involving the A $^1\Sigma_u$ state of Na_2, and the stability of the Na_2^- ion is established.

15816. Lias, S. G., Ausloos, P., **Book: Ion-molecule reactions. Their role in radiation chemistry,** *Second ACS/ERDA Research Monograph in Radiation Chemistry*, **2,** 205 pages (American Chemical Society, Washington, DC, 1975).

Key words: hydride transfer; ion clustering; ion-molecule reactions; proton transfer; radiation chemistry.

In this monograph, information is examined about ion-molecule reactions occurring in various kinds of systems, making wherever possible a synthesis of the information obtained through the several mass spectrometric techniques, as well as from organic chemistry, NMR studies, theoretical calculations and from radiolytic studies themselves. A chapter has been included which presents what is known about the effects of density on ionic fragmentation processes and on ionic isomerization processes. A chapter on charge recombination in the gas and liquid phases has been included. The kinetics of the reactions of thermal ions with molecules, are also reviewed. Other chapters treat one- and two-atom transfer reactions, ion-molecule condensation processes, and ionic solvation or clustering.

15817. Martin, G. A., Wiese, W. L., **Atomic oscillator-strength distributions in spectral series of the lithium isoelectronic sequence,** *Phys. Rev. A* **13,** No. 2, 699-714 (Feb. 1976).

Key words: continuum; discrete spectrum; *f*-sum rule; *f*-values; lithium sequence; oscillator strength distribution; oscillator strengths; relativistic effects; spectral series; systematic trends.

We describe a new type of analysis yielding the oscillator-strength distributions in several spectral series throughout the lithium isoelectronic sequence. Individual oscillator strengths have been critically evaluated and tied together by requiring that they fulfill simultaneously four basic spectroscopic constraints: (a) regularities for individual transitions along the isoelectronic sequence, (b) regularities for the transitions of a spectral series, (c) compliance with the requirement of continuity across the spectral series limit, and (d) adherence to *f* sum rules. With only slight modifications, the best available data fulfill closely all four requirements. The final set of *f*-value data—which are tabulated and partly presented in illustrations—possess, therefore, a very high degree of internal consistency and reliability. Relativistic corrections for very highly charged Li-like ions are also considered.

15818. Olver, F. W. J., **Unsolved problems in the asymptotic estimation of special functions,** Paper in *Theory and Application of Special Functions*, R. A. Askey, Ed., pp. 99-142 (Academic Press, Inc., New York, NY, 1975).

Key words: asymptotic analysis; Darboux's method; definite integrals; hypergeometric functions; incomplete gamma function; Legendre functions; ordinary differential equations; saddle points; special functions; turning points; Whittaker functions.

The first part of this paper surveys the tools of asymptotic analysis that are presently available and those that are needed for the next stages of development of the asymptotic theory of special functions. Methods are grouped according to the number of free variables to which they achieve a uniform reduction. Topics include the approximation of functions defined parametrically by a definite integral or infinite sum, and approximate solutions of linear ordinary differential equations. The main areas in which work appears to be needed are (i) problems of confluence, that is, coalescing saddle points and singularities of integrals, or coalescing turning points and singularities of differential equations; (ii) rigorous error analysis.

The second part of the paper discusses the more important special functions in increasing order of the total number of variables and parameters involved. Almost all asymptotic problems concerning special functions of one variable have been solved. For functions of two variables the problems are solved, or can be solved by use of existing asymptotic tools. It is in the case of functions depending on three variables (including parameters) that the most significant work can be expected in the immediate future. Two new asymptotic tools have been developed very recently, one for integrals with three coalescing saddle points, the other for second-order differential equations having two coalescing turning points. Applications of these tools are needed, as well as the development of similar tools for other three-variable problems involving confluence. As the total number of variables increases beyond three, our knowledge of the asymptotic behavior of the special functions becomes more fragmentary. It will undoubtedly be many years before we have complete knowledge of the asymptotic behavior of any of the functions of four variables, including for example, the hypergeometric function F(a,b;c;z).

15819. Franklin, A. D., **Electrode effects in the measurement of ionic conductivity,** *J. Am. Ceram. Soc.* **58,** No. 11-12, 465-473 (Nov.-Dec. 1975).

Key words: electrode polarization; impedance measurements; interfaces; ionic conductivity; overpotential; solid electrolyte.

Even with thermodynamically reversible electrodes, slow processes inhibiting the discharge of ions at the interface between a solid ionic conductor and the electrode can give rise to overvoltages when current is passed or to an interface impedance in ac measurements. Some of the more important of the mechanisms responsible for this inhibition, i.e., boundary layers, slow charge-transfer processes with double-layer formation, product storage in the electrodes with slow mass transport to the ultimate thermodynamic reservoirs, and rough or porous surfaces, can be understood in a nonrigorous physical way with the help of simple models. The properties of such systems can often be expressed in terms of equivalent circuits, and these are then very useful in analyzing the behavior of specific systems. Examples from studies of materials such as CaO-stabilized ZrO_2 (oxygen-ion conductor) and β-Al_2O_3 (sodium-ion conductor) illustrate these effects.

15820. Franklin, A. D., **Equilibria among point defects in GdF_3-doped CaF_2,** *J. Chem. Phys.* **64,** No. 4, 1509-1515 (Feb. 15, 1976).

Key words: annealing; calcium fluoride; defect pairs; equilibria; model; point defects.

EPR and dielectric relaxation measurements, reported earlier, have been combined to produce estimates of the mole fraction (n') of pairs formed of substitutional Gd^{3+} ions and F^- interstitials as a function of total GdF_3 mole fraction (M) and temperature at which the crystals are annealed prior to rapid cooling. Over the range of M from 1×10^{-4} to 27×10^{-4}, n' rises to a saturation value when M increases to about 10^{-3}. At constant M, n' goes through a maximum at anneal temperatures from about 1073 to 1273 K. The rate of the annealing reaction increases with M and with decreasing sample size, and the density increases with increasing M faster than the interstitial model predicts. A qualitative model of the annealing process is suggested, in which F^- interstitials react with an atmospheric constituent (probably HF) to form an immobile complex that provides remote charge compensation for the cubic Gd^{3+} ions. The remaining free F^- interstitials are trapped by Gd^{3+} ions during quenching to form the pairs.

15821. Wiederhorn, S. M., **Crack growth as an interpretation of static fatigue,** *J. Non-Cryst. Solids* **19,** 169-181 (1975).

Key words: crack growth; fracture; fracture mechanics; glass; static fatigue; strength.

Static fatigue is due to water in the environment which accounts for substantial reductions in the strength of glass. Extensive experimental investigations have shown that static fatigue results from surface cracks that grow when glass is subjected to tensile loads. In this paper evidence for this conclusion is reviewed. First, the earlier studies of strength of glass are summarized. Then, supporting evidence for crack growth obtained from the newer discipline of fracture mechanics is given. Finally, the influence of ion exchange and chemical reactions at crack tips is discussed with regard to crack growth. The chemical composition of the crack-tip solution is shown to play an important role in controlling crack growth.

15822. Lawn, B. R., Fuller, E. R., **Equilibrium penny-like cracks in indentation fracture,** *J. Mater. Sci.* **10,** 2016-2024 (1975).

Key words: contact fracture; degradation; Hertzian cracks; indentation fracture; median vents; penny crack.

A study is made of the mechanics of two basic types of indentation fracture, cone cracks ("blunt" indenters) and median cracks ("sharp" indenters). The common feature which forms the central theme in this work is that both crack types, in their well-developed stages of growth, may be regarded as essentially "penny-like." On this basis a universal similarity relation is derived for equilibrium crack dimension as a function of indentation load. Experimental measurements confirm the general form of this relation. A more detailed fracture mechanics analysis is then given, to account for additional, contact variables evident in the data. Notwithstanding certain analytical limitations, the study serves as a useful basis for investigating a wide range of contact-related problems, both fundamental and applied, in brittle solids.

15823. Cali, J. P., **International criteria for reference materials,** (Proc. VI Int. Symp. on Quality Control in Clinical Chemistry, Geneva, Switzerland, Apr. 1975), Paper in *Quality Control in Clinical Chemistry,* pp. 369-383 (Walter de Gruyter & Co., Geneva, Switzerland, 1976).

Key words: reference materials.

In clinical chemistry, international organizations are now becoming aware of and taking steps to integrate national measurement programs for use in the international scene. The steps necessary to bring about compatible measurement networks in clinical chemistry are briefly discussed—mainly in the context of the measurement process. Reference materials, as well as definitive and reference methods are important elements in the building and maintenance of a compatible measurement system.

International criteria for reference materials, especially those that are certified are recommended. Factors to be considered include: purity, homogeneity, stability, continuity of supply and information, availability, and the certification process, including legally imposed requirements. Each of these is discussed, together with examples drawn from the NBS clinical Standard Reference Materials.

15824. Mihalas, D., Kunasz, P. B., Hummer, D. G., **Solution of the comoving-frame equation of transfer in spherically symmetric flows. II. Picket-fence models,** *Astrophys. J.* **203,** No. 3, 647-659 (Feb. 1, 1976).

Key words: radiative transfer—stars; winds.

To examine the effect of the radial flow of atmospheric material on the temperature distribution in a stellar atmosphere, a picket-fence model with Gaussian lines is formulated and solved numerically in the comoving frame of the gas, which is assumed to move with a prescribed velocity law. Extensive results have been obtained for both static and dynamical models, with planar and moderately extended spherical geometries. For static models, the effect of lines on the temperature distribution is virtually independent of extension. When a large-scale velocity field is imposed, significant surface heating and additional back-warming are found; the magnitude of these effects increases with the extension of the atmosphere. If a significant flow velocity persists to sufficient depth, the enhanced escape probability can lead to a cooling in the deeper layers, which competes with the back-warming. The results obtained here suggest that the deposition of energy arising from the intrusion of line opacity into the continuum, caused by velocity gradients, could influence the dynamics of the flow.

15825. Hockey, B. J., **Pyramidal slip on {1123} ⟨1100⟩ and basal twinning in Al_2O_3,** (Proc. Symp. on Plastic Deformation of Ceramic Materials, Pennsylvania State Univ., University Park, PA, July 17-19, 1974), Chapter in *Deformation of Ceramic Materials,* R. C. Bradt and R. E. Tressler, Eds., Sec. II, pp. 167-179 (Plenum Press, New York, NY, 1975).

Key words: aluminum oxide; microhardness; plastic deformation; slip; transmission electron microscopy; twinning.

Plastic deformation of Al_2O_3 by slip and twinning has been investigated by examining the regions surrounding a microhardness indentation using transmission electron microscopy (TEM). The results establish: (1) the occurrence of pyramidal slip on {1123} ⟨1100⟩, and (2) the nature of basal twins in this material. The observations on basal twins, in particular, have led to a completely different description for the twinning process, which is briefly described.

15826. Massey, R. G., **The police patrol car: State of the art,** *LESP-RPT-0403.00,* 33 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, July 1975).

Key words: functional requirements; patrol cars; performance of patrol cars; police patrol cars; problems with patrol cars; state of the art survey.

This report, entitled "The Police Patrol Car: State of the Art" describes the functional requirements of police agencies for patrol cars, the manner in which these requirements are met, or not met, by vehicles currently in use, and a discussion of new automotive technology which might affect patrol car performance in the future.

15827. Baird, R. C., Kerns, D. M., **The accurate determination of millimeter-wave antenna characteristics by deconvolution and extrapolation techniques,** *Proc. Millimeter-Wave Techniques Conf., San Diego, CA, Mar. 26-28, 1974,* **2,** pp. E2-1—E2-12 (Naval Electronics Laboratory Center, San Diego, CA, 1974).

Key words: antenna gain, polarization and pattern; deconvolution; extrapolation; fields and antennas.

The newly-developed methods are described for determining accurate far-field characteristics of antenna gain, polarization, and pattern by using near-field measurements at reduced distances. These methods have no restrictive assumptions or approximations, are useful at microwave and millimeterwave frequencies, and are applicable to directive antennas of all types.

15828. Allred, C. M., Manney, C. H., **The calibration and use of directional couplers without standards,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 1, 84-89 (Mar. 1976).

Key words: directional coupler; measurement standards; self-calibration.

Basic principles and suggested techniques are presented for calibrating nonideal four-port couplers without standards. Under the assumption that the complex ratio of the side-arm voltages are known, all the parameters, except one of the directional couplers, can be determined without recourse to known values of impedances, shorts, opens, etc. Also, the surprising number of measurements that can be made with such an incompletely calibrated coupler are discussed.

15829. Hermach, F. L., Road, R. A., **Changes in metering covered by revised ANSI code,** *Transmission & Distribution* **28,** No. 3, 24-25, 44 (Mar. 1976).

Key words: code; definitions; demand meters; electricity metering; performance requirements; standards; test methods; watthour meters.

The major changes and additions in the new 1975 edition of the American National Standard "Code for Electricity Meters" are described briefly. This 200-page code, which is widely used, gives performance criteria and test methods for watthour meters and associated equipment. The new edition, replacing the 5th edition of 1965, lengthens tests intervals for highly stable modern meters, extends sample testing, gives performance requirements for the first time for standard meters and pulse recorders, and has many other changes.

15830. Phelan, R. J., Jr., Hamilton, C. A., Day, G. W., **Radiometry without standard sources/electrically calibrated pyroelectrics,** (Proc. Society of Photo-Optical Instrumentation Engineers, San Diego, CA, Aug. 17-22, 1975), Paper in *Modern Utilization of Infrared Technology Civilian and Military, SPIE* **62,** 159-165 (Society of Photo-Optical Instrumentation Engineers, Palos Verdes Estates, CA, 1975).

Key words: optical radiation; pyroelectrics; radiometers.

A radiometer using an electrically calibrated pyroelectric detector has been developed. The system, using a number of unique concepts, was designed to be a truly useful measurement tool for optical radiation of wavelengths from 0.4 to beyond 12 μm at power levels of microwatts. No standard sources are required for calibrations.

15831. Schwarz, F. P., Wasik, S. P., **Fluorescence measurements of benzene, naphthalene, anthracene, pyrene, fluoranthene, and benzo[*e*]pyrene in water,** *Anal. Chem.* **48,** No. 3, 524-528 (Mar. 1976).

Key words: absorption; carcinogenic; fluorescence; polycyclic aromatic hydrocarbons; quantum yields; water.

Fluorescence spectra, quantum yields, and concentration dependencies are reported for five representative polycyclic aromatic hydrocarbons (PAH) in water to ascertain the applicability of measuring PAH in aqueous systems by spectrofluorimetry. The fluorescence quantum yields of benzene, naphthalene, anthracene, pyrene, fluoranthene, and benzo[*e*]pyrene in water are, respectively, $5.3\pm0.5\times10^{-3}$, 0.16 ± 0.02, 0.25 ± 0.02, 0.69 ± 0.06, 0.20 ± 0.01, and $\sim0.3\pm0.1$. With the exception of pyrene, oxygen quenching of the fluorescence in water is at most 30 percent. The fluorescence concentration dependence was measured by photon counting the fluorescence intensity relative to the excitation light intensity. All the PAH fluorescences exhibited a linear dependency on the concentration. For a fluorescence signal-to-noise ratio of 1, the detection limits are as follows: naphthalene, 0.03 μg/l., anthracene, 0.03 μg/l., pyrene, 0.15 μg/l., fluoranthene, 0.17 μg/l., and benzo[*e*]pyrene, 0.10 μg/l.

15832. Strobridge, T. R., **Open discussion of large scale cryogenic refrigeration,** Conference Report – Applied Superconductivity Conference, Oakbrook, IL, Sept. 30-Oct. 1-2, 1974, *Cryogenics* **15,** No. 3, 157-158 (Mar. 1975).

Key words: cryogenic; helium; meeting summary; refrigeration; superconductivity.

A discussion session on Large Scale Refrigeration held at the 1974 Applied Superconductivity Conference is summarized.

15833. Sawyer, D. E., Berning, D. W., **Laser scanning of MOS IC's reveals internal logic states nondestructively,** *Proc. IEEE Letters* **64,** No. 3, 393-394 (Mar. 1976).

Key words: active devices; laser scanning; logic flow observation; LSI testing; measurement of operating margins; nondestructive tests; P-MOS shift register.

A laser scanning system has been used to observe the internal logic pattern in a MOS LSI device in a nondestructive manner. The laser scanner has also been used to selectively change logic states deep within the device. Pictures of the logic patterns revealed by the scanner are discussed.

15834. Kasa, I., **A circle fitting procedure and its error analysis,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 1, 8-14 (Mar. 1976).

Key words: circle fitting; error analysis.

An efficient circle fitting procedure and its general random-error analysis are described. The first-order random errors of the center coordinates and the radius of the fitted circle are discussed in detail. The effect of the data point distribution along the circle is investigated, and for an important microwave application (sliding termination measurements) the frequency dependence is also evaluated.

The effects of the second-order error terms are also discussed and general formulas are given. Finally an estimation of data point error is provided.

15835. Lawton, R. A., Andrews, J. R., **Optically strobed sampling oscilloscope,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 1, 56-60 (Mar. 1976).

Key words: GaAs; laser; optical; oscilloscope; photoconductor; picosecond; sampling; sampling oscilloscope; strobe.

An optically strobed sampling oscilloscope is described which uses optical pulses from a GaAs laser diode to strobe a Cr-doped GaAs photoconductor which serves as a sampling gate. This sampling gate has been used with a commercial sampling oscilloscope to provide a sampling measurement capability that can measure higher voltages than conventional samplers and does not exhibit strobe pulse kickout. Preliminary tests indicate a time resolution, limited by the width of the optical pulse used, of about 100 ps.

15836. Engen, G. F., **Mismatch considerations in evaluating amplifier noise performance,** *IEEE Trans. Instrum Meas.* **IM-22,** No. 3, 274-278 (Sept. 1973).

Key words: amplifier noise performance; mismatch considerations.

In terms of a total system evaluation, the potential mismatch errors in the evaluation of noise figure or effective input noise temperature are of greater magnitude than is the case in power measurement. In spite of this, this topic has found only limited

coverage in the literature. Moreover, the existing treatments are in terms of parameters whose evaluation requires a significant effort. This paper applies a "terminal invariant" formulation which provides a deeper physical insight to this problem. It also permits a number of useful conclusions to be drawn with a minimum of additional effort.

15837. Levin, B., **Psychological characteristics of firesetters,** *Fire J.* **70,** No. 2, 36-41 (Mar. 1976).

Key words: arson; firesetting; psychopathic personality.

A wide variety of medical, criminology and fire journals have dealt with the psychopathology of firesetting. Although contradictory conclusions are quite common, there is general agreement on some aspects of the problem. Firesetters tend to come from broken or disrupted homes and to have lived under harsh or frustrating circumstances. However, this is also true of many criminals. Firesetters tend to be young, to be of low intelligence, to have been bedwetters as children, to have a stronger than average interest in fire, and to have physical deformities. Many of these conclusions are based on studies published over 25 years ago. There is a great need for up-to-date information regarding the firesetters of the 1970's.

15838. Fickett, F. R., **Properties of nonsuperconducting technical solids at low temperatures—An update,** (Proc. 5th Int. Conf. on Magnet Technology, Rome, Italy, Apr. 21-25, 1975), Paper in *Magnet Technology,* N. Sacchetti, M. Spadoni, and S. Stipcich, Eds., pp. 659-678 (Laboratori Nazionali del CNEN, Frascati, Italy, 1975).

Key words: cryogenics; materials; mechanical properties; review, thermal properties.

This review presents properties measurements carried out on structural materials, both metallic and nonmetallic, at low temperatures. It is a sequel to the paper presented at the preceding conference and, as such, concentrates on measurements reported over the last two years. These years have been a period of intense activity in this field and a great deal of new data has been obtained, particularly on mechanical properties. Specific topics covered are thermal, magnetic, mechanical and fracture properties of materials. A tabular guide to the literature is included.

15839. Schwarz, F. P., Wasik, S. P., **Fluorescence measurements of carcinogenic and polycylic aromatic hydrocarbons in water,** (Proc. Int. Conf. on Environmental Sensing and Assessment, Las Vegas, NV, Sept. 14-19, 1975), Paper in *International Conference on Environmental Sensing and Assessment* **2,** Session 30-2, 1-5 (Institute of Electrical and Electronics Engineers, New York, NY, 1976).

Key words: carcinogenic compounds; partition coefficient; photon counting; polycyclic aromatics; spectrofluorimetry; water.

The application of spectrofluorimetry to the measurement and identification of polycyclic aromatic hydrocarbons (PAH) in aqueous solutions was investigated. At naperian absorbances ≤ 0.05, the fluorescence intensities of solutions containing naphthalene, anthracene, pyrene, and fluoranthene in water are a superposition of the component fluorescence spectra. At the higher PAH optical densities of the mg/l level and when viewed perpendicular to the excitation light, the fluorescence spectra vary unpredictably with the concentration. The PAH fluorescence intensity is unaffected by the presence of sodium chloride at sea water concentrations and by the presence of mg/l concentrations of iron, zinc, cobalt, or nickel cations in the water.

15840. Laughlin, D. E., **Spinodal decomposition in nickel based nickel-titanium alloys,** *Acta Metall.* **24,** pp. 53-58 (1976).

Key words: Ll_2; metastable phase; ordering reaction; satellites; spinodal decomposition; superlattice reflections; transmission electron microscopy; δ'.

The early stages of the decomposition process in Ni based Ni-Ti alloys have been studied by means of transmission electron microscopy. It was found that the supersaturated solid solution of Ti in Ni decomposes by the spinodal mechanism into periodic and aligned regions which are Ti rich and Ti lean. After a critical amount of Ti enters the Ti rich regions, they order continuously to the $Ll_2(Cu_3Au)$ structure. The two processes then continue together until the fully ordered metastable γ' particles are formed.

15841. Herbst, J. F., Watson, R. E., Wilkins, J. W., **4*f* excitation energies in rare-earth metals: Relativistic calculations,** *Phys. Rev. B* **13,** No. 4, 1439-1445 (Feb. 15, 1976).

Key words: photoelectron spectroscopy; rare earth metals; 4*f* electron excitations.

We describe calculations of 4*f* electron binding energies for the rare-earth metals. Relativistic Hartree-Fock calculations for atomic configurations most closely approximating those of the metals are initially performed, and crystal potentials are constructed by means of the renormalized-atom method. Relativistic band calculations are iterated to crude self-consistency and total band energies obtained. Correlation effects identical to those in the free atoms are assumed. Within the assumption of a completely screened final state, in which the atomic site having the 4*f* hole is electrically neutral, 4*f* binding energies are estimated which are in at least as good agreement with experiment as previous, less complete calculations. The impact of the complete screening approximation is assessed by estimating the binding energies corresponding to atomic sites which are ionized in their final states; we find that the presence of an additional screening electron lowers the 4*f* binding energy by 4 – 6 eV.

15842. Watson, R. E., Herbst, J. F., Hodges, L., Lundqvist, B. I., Wilkins, J. W., **Effect of ground-state and excitation potentials on energy levels of Ni metal,** *Phys. Rev. B* **13,** No. 4, 1463-1467 (Feb. 15, 1976). 350

Key words: band structure; energy levels; excitation potential; ground state potential; nickel.

Self-consistent energy-band calculations for paramagnetic Ni have been performed in an effort to compare ground-state and excitation potential prescriptions; potentials of the Hartree-Fock-Wigner-Seitz and Hedin-Lundqvist type are examined. We find the bandwidth and placement of the Fermi level within the bands to be rather insensitive to the choice of potential, while the absolute position of the bands with respect to the appropriate reference energy is potential dependent. Use of the Hedin-Lundqvist excitation potential instead of the ground-state potential produces level differences no greater than 0.1 eV.

15843. Penn, D. R., **Electron attenuation lengths for free-electron-like metals,** *J. Vac. Sci. Technol.* **13,** No. 1, 221-223 (Jan.-Feb. 1976).

Key words: bulk; electron mean free path; exchange and correlation; jellium.

Mean free paths for electrons in bulk jellium are calculated for hot electrons with energies from a few hundred to a few thousand electron volts and for values of r_s from 1.5 to 5. Exchange and correlation effects are included and the results are compared to relevant experiments.

15844. Coriell, S. R., Sekerka, R. F., **Morphological stability near a grain boundary groove in a solid-liquid interface,** (Proc. 4th Soviet Conf. on Crystal Growth, Tsakhkadzor, Armenia,

Sept. 16-23, 1972), Paper in *Growth of Crystals* **11,** 230-262 (1975).

Key words: grain boundary; morphology; solidification; stability.

For constant velocity solidification of a pure substance or a dilute binary alloy, the time-dependent shape of a nearly planar interface, intersected perpendicularly by a grain boundary, is calculated. For certain growth parameters, a stable groove shape is found; otherwise an unstable mode of grain boundary grooving occurs. The stability-instability demarcation agrees exactly with morphological stability theory for an interface not containing a grain boundary. Under certain conditions, the stable shape is an oscillatory function.

15845. Ederer, D. L., Lucatorto, T. B., Saloman, E. B., Madden, R. P., Manalis, M., Sugar, J., **Photoabsorption of the 4*d* electrons in xenon and barium: A comparison,** (Proc. Int. Symp. on Electron and Photon Interactions with Atoms, in honor of Prof. Ugo Fano, Univ. of Stirling, Scotland, July 16-19, 1974), Chapter in *Electron and Photon Interactions with Atoms,* H. Kleinpoppen and M. R. C. McDowell, Eds., pp. 69-81 (Plenum Press, New York, NY, 1976).

Key words: atomic structure; barium; N_{IV} edges; spectroscopy; vacuum ultraviolet; 4*d* photoabsorption.

The 4*d* absorption spectra of xenon and barium show very different behavior. In xenon the cross section has been measured for two series of resonances converging to the $4d^9(^2D_{5/2,3/2})$ limit. By a parameterization technique, the amplitudes and widths of these resonances have been obtained. The widths of the resonances are essentially constant, but the widths of the resonances converging to the $4d^9(^2D_{5/2})$ limit (N_V edge) are somewhat narrower than those converging to the $4d^9(^2D_{3/2})$ limit (N_{IV} edge). The oscillator strength in these $4d^9(^2D_{5/2,3/2})np$ series is small (0.06) compared to the total continuum oscillator strength integrated over open *p* and *f* channels. The barium spectrum is very different from the xenon spectrum because the 4*f* orbital contracts in excited barium and overlaps the 4*d* orbit. This contraction produces two terms, ^3P and ^3D, of the $4d^94f$ configuration below the 4*d* ionization limits, while the strong electrostatic exchange interaction drives the ^1P term of this configuration some 10 eV above the limit. Furthermore, extensive mixing of the $4d^96s^26p$ configuration with $4d^95d^26p$ and $4d^95d6s6p$ produces many weak resonances near the $4d^{10}\rightarrow 4d^9(^2D_{5/2})6s^26p(^2P_{3/2})$ resonance. A suggested classification of these features is given with the aid of known features of the La I spectrum. Finally, from the known x-ray splitting of the $N_{IV,V}$ threshold and the energy interval between the $6s^26p(^2P)$ and $6s^2(^1S)$ levels in La I and La II, the ionization thresholds of the 4*d* electron were determined to be 814,800(1000) cm^{-1} and 792,500(1000) cm^{-1}.

15846. Hutchinson, J. M. R., Mullen, P. A., **Standardization and ground-state branching of selenium-75,** *Int. J. Appl. Radiat. Isot.* **27,** No. 1, 47-50 (Jan. 1976).

Key words: coincidence counting; gamma rays; ground state decay; radioactivity; selenium-75; standardization.

Selenium-75 is much used as a radioactive tracer in nuclear medicine. Several thousand administered doses of selenium-75 compounds are given per year in the U.S. for liver scanning and other purposes. Although accuracies of only ±10 percent in activity measurements are required by the U.S. Pharmacopoeia, more accurately calibrated sources of selenium-75 are useful in nuclear medicine for the calibration of detectors in the energy region from 97 keV to 401 keV since γ-ray abundances are known to a few percent in most cases. For this and other reasons, the National Bureau of Standards (NBS) has developed, by means of an X-γ coincidence counting method, a radioactivity standard of selenium-75, and, at the same time, determined the poorly-known fraction, f_g, of selenium-75 disintegrations going directly to the ground state of arsenic-75.

f_g has been calculated in this work from the difference between the measured value for the activity of a sample and its measured total γ-ray emission rate, using the NBS 8-in. NaI(Tl) detector system. Most selenium-75 disintegrations produce a response in this system because of its high γ-ray detection efficiency and because most disintegrations produce two or more γ-rays. Values have been reported for f_g ranging from $<10^{-3}$ to 0.04. The Nuclear Data Tables, taking a weighted average of published values, quotes f_g=0.023±0.023 (uncertainty of 2σ).

The value of f_g determined by us was zero, with a 99 percent probability of being less than 1.2 percent.

The measured value for the activity is independent of all decay-scheme parameters, except conversion-electron intensities (which are known to ±4 %) and the probability of K capture, which appears in a small correction term.

15847. McKee, R. A., **Thermomigration of interstitial-solute-vacancy pairs in a dilute fcc alloy,** *Phys. Rev. B* **13,** No. 2, 635-640 (Jan. 15, 1976).

Key words: diffusion; dilute alloys; interstitial solute vacancy pairs; kinetic theory; pair association method; thermomigration.

The influence of a temperature gradient on the motion of an interstitial-solute-vacancy pair in a fcc alloy has been analyzed using the "pair association" kinetic theory developed by Lidiard. In the past, an interstitial-solute-vacancy pair mechanism has been used to describe the diffusion of various solutes in the group-IV elements, and this development for the kinetics of the thermomigration of such solute-vacancy pairs can be used for further evaluation of this proposed mechanism for diffusion in these alloys.

15848. Waterstrat, R. M., **Comments on possible "*B*-site" disorder in A15 (β-*W* type) compounds,** *Solid State Commun.* **18,** No. 4, 531-532 (1976).

Key words: atomic ordering; A15 compounds; intermetallic compounds; nonstoichiometry; phase composition; phase stability.

In a recent paper evidence for "preferential *B*-site disorder" in A15 compounds was presented. It can be shown, however, that the data in this paper lead to serious disagreements between predicted and observed phase compositions. Thus, the methods used are of doubtful validity and it is suggested that a more accurate knowledge of the phase compositions is needed.

15849. Beers, Y., Howard, C. J., **The spectrum of DO_2 near 60 GHz and the structure of the hydroperoxyl radical,** *J. Chem. Phys.* **64,** No. 4, 1541-1543 (Feb. 15, 1976).

Key words: chemical structure; hydroperoxyl; microwave.

Spectra for the lowest rotational transition in DO_2, $N=1\leftarrow 0$, have been observed near 60 GHz. These data have been used to calculate the sum of the rotational constants $B+C$ for DO_2=60 467.7±3 MHz. This result was combined with other measurements on HO_2 to compute a structure for the hydroperoxyl radical: $r(H-O)=0.977\times10^{-10}$ m, $r(O-O)=1.335\times10^{-10}$ m, and $<H-O-O=104.1°$. Also we have found for DO_2 that $(\epsilon_{bb}+\epsilon_{cc})/2=-191\pm3$ MHz for elements of the electron-spin rotation tensor and a value of -4.2 ± 1.5 MHz for the Fermi contact interaction parameter σ.

15850. Sieck, L. W., Gorden, R., Jr., **Formation of dimeric parent cations in aromatic hydrocarbons,** *Int. J. Mass Spectrom. Ion Phys.* **19,** No. 3, 269-286 (1976).

Key words: gas phase; hydrocarbons; kinetics; mass spectrometry; photoionization; rate constants.

Third-order rate coefficients have been determined at 295 K for the formation of dimeric parent cations in benzene, benzene-d_6, toluene, the xylenes, mesitylene, and fluoro- and chlorobenzene using the NBS high pressure photoionization mass spectrometer. The reactions are all quite fast, the rate coefficients falling in the range $0.5-6\cdot10^{-25}$ cm^6 molecule^{-2} s^{-1}. The differences in rates observed are rationalized in terms of structural (geometric) considerations, and upper limits are established for the binding energies in $(C_6H_6)_2^+$ and $(C_6H_5CH_3)_2^+$. The temperature dependence for production of $(C_6D_6)_2^+$ has been determined from 227 to 316 K, and the rate coefficient seems to obey a simple $1/T$ relationship over this range. The detection of trimeric species in benzene is also reported for the first time. Additional experiments involving benzene-nitric oxide mixtures are also reported, which include detection of an apparent equilibrium of the type $NO^+ + C_6H_6 \rightleftarrows C_6H_6^+ + NO$.

15851. **Vorburger, T. V., Sandstrom, D. R., Waclawski, B. J., UPS studies of virgin CO on W(100),** *J. Vac. Sci. Technol.* **13,** No. 1, 287-290 (Jan.-Feb. 1976).

Key words: adsorption; carbon monoxide; chemisorption; desorption; photoelectron spectroscopy; photoemission; single crystal; tungsten; ultraviolet photoelectron spectroscopy; virgin CO.

The adsorption of CO on W(100) at 80 K has been studied by photoelectron spectroscopy at $h\nu$=21.22 eV, and the results have been correlated with previous data for room temperature adsorption. Initial adsorption produces a peak in the emission spectrum at ~ -7.6 eV (relative to the Fermi energy), which is characteristic of the virgin state of adsorbed CO, as well as additional structures which have been previously shown to be characteristic of α- and β-CO. Upon heating the sample to 260 K the -7.6-eV level is depleted and apparent conversion to the β state occurs as indicated by an enhancement of the emission near -5.5 eV. Additional data taken with $h\nu$=16.85, 26.9, and 40.81 eV are in general agreement with the measurements at 21.22 eV; however, the peak at -7.6 eV for $h\nu$-21.22 eV is shifted to lower kinetic energies by several tenths of an electron volt at the other photon energies.

15852. Miller, A., McLaughlin, W. L., **Holographic measurements of electron-beam dose distributions around inhomogeneities in water,** *Phys. Med. Biol. Tech. Note* **21,** No. 2, 285-288 (1976).

Key words: absorbed dose; calorimetry; dose distributions; dosimetry; electron beams; holography; interferometry; water phantoms.

Holographic interferometry employing temperature-induced changes of the refractive index of water has been used to measure absorbed dose distribution around an aluminum-rod immersed in water and exposed to a 3-MeV electron beam.

15853. Grant, W. H., Smith, L. E., Stromberg, R. R., **Adsorption and desorption rates of polystyrene on flat surfaces,** *Faraday Discuss. Chem. Soc.*, No. 59, 209-217 (1975).

Key words: adsorption; adsorption on mercury; desorption; polymers; polystyrene; radiotracer measurements; rates of adsorption; surfaces.

The rates of adsorption and desorption of polystyrene have been measured in cyclohexane and benzene solutions by radiotracer techniques. Relatively long times were required to attain maximum adsorbance values for adsorption of both low and high molecular weight polymer on a solid chrome surface under theta conditions. This was interpreted as indicating a molecular reorientation during the adsorption process. Under these conditions it was observed that the maximum adsorbance values increased with increasing molecular weight, but the amounts adsorbed were independent of molecular weight at very short adsorbance times. This was interpreted as indicating two separate rates of adsorption: an initial rate dependent on the rate of arrival and attachment at the surface and the rate of rearrangement on the surface. More rapid attainment of maximum adsorbance values on a mercury surface was attributed to participation of the liquid mercury surface in accommodating the changing polymer conformation. The rates of desorption were very slow for both chrome and mercury and were dependent on the surface populations as determined by the adsorbance values.

15854. Utton, D. B., Bowers, W. J., Jr., **Demountable seal between an epoxy resin and copper for low-temperature applications,** *Rev. Sci. Instrum.* **47,** No. 3, 382-383 (Mar. 1976).

Key words: cryogenic temperatures; epoxy resin-copper seal; indium O-ring.

We describe an indium O-ring seal between an epoxy resin and copper. It is simple, reliable, can withstand severe thermal shocks, and is leaktight to superfluid helium.

15855. Powell, C. J., **Cross sections for ionization of inner-shell electrons by electron impact (Abstract),** *J. Vac. Sci. Technol.* **13,** No. 1, 219-220 (Jan.-Feb. 1976).

Key words: Auger-electron spectroscopy; cross sections; electron probe microanalysis; electrons; inner-shell.

A survey has been made of inner-shell ionization cross-section data in the range of interest for quantitative Auger-electron spectroscopy. Calculated, semiempirical and experimental data have been intercompared graphically and by deriving "effective" values of the Bethe parameters b_{nl} and c_{nl} from fits of cross sections σ_{nl} to a linearized form of the Bethe equation for inner-shell ionization. These intercomparisons were made for values of the parameter $U_{nl}(=E_0/E_{nl}$, where E_0 is the incident electron energy and E_{nl} the binding energy of electrons in the nl-shell) between 4 and about 30. The derived values of b_{nl} were generally consistent with those expected from photoabsorption data if account was taken of the distribution of differential oscillator strength with respect to excitation energy and the resultant expected variation of b_{nl} near threshold. Experimental values of $\sigma_K E_K^2$ plotted as a function of U_K appeared to lie on a common curve and agreed well with the calculations of Rudge and Schwartz and of McGuire. A greater spread existed in similar plots of calculated and measured values of $\sigma_L E_L^2$ as a function of U_L, but the magnitude of a variation with Z could not be definitely established on account of discordant data.

15856. Lawn, B. R., Wiederhorn, S. M., Johnson, H. H., **Strength degradation of brittle surfaces: Blunt indenters,** *J. Am. Ceram. Soc.* **58,** No. 9-10, 428-432 (Sept.-Oct. 1975).

Key words: brittle solids; ceramic surfaces; crack; degradation; fracture; Hertzian; indentation; strength.

Indentation fracture mechanics is used to develop a theoretical basis for predetermining the strength properties of brittle surfaces in prospective contact situations. Indenters are classified as blunt or sharp; only the first is considered in the present work. The classical Hertzian cone crack conveniently models the fracture damage incurred by the surface in this class of indentation event. Significant degradation is predicted at a critical contact load; when the load is increased beyond this critical level, further degradation occurs at a relatively slight rate. Bend tests on

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abraded glass slabs confirm the essential features of the theoretical predictions. The controlling variables in the degradation process, notably starting flaw size and indenter radius, are investigated systematically. An indication is also given as to optimization of material parameters.

15857. Gadzuk, J. W., **Can chemisorption bonding shifts be separated from relaxation-energy shifts in photoelectron spectroscopy? (Abstract),** *J. Vac. Sci. Technol.* **13,** No. 1, 343-344 (Jan.-Feb. 1976).

Key words: chemisorption; photoemission; relaxation energy; surface plasmons.

A theory for separating relaxation energy shifts from chemical bonding shifts in photoelectron spectra of chemisorbed atoms is presented.

15858. Flynn, J. H., Dickens, B., **Steady-state parameter-jump methods and relaxation methods in thermogravimetry,** *Thermochim. Acta* **15,** 1-16 (1976).

Key words: degradation; kinetics; oxidation; parameter jump method; polystyrene; relaxation methods; thermogravimetry; weight-loss.

We describe a technique for thermogravimetric analysis in which the magnitude of a rate-forcing variable such as temperature, pressure, gaseous flow-rate, gaseous composition, etc., is jumped by discrete steps. This method can be used to determine kinetic relationships between the rate of weight-loss and the jumped variable. The method avoids the disparate effects of separate experimental histories in methods in which two or more experiments are compared. The necessity for guessing the often complex rate vs. extent of reaction relationship in methods where the rate forcing variable is changed continuously in a single experiment is also avoided. The method is illustrated with examples from the oxidation of polystyrene.

Techniques involving multiple jumps and more complex programming are proposed. The fruitful investigation of weight-loss kinetics by the measurement of relaxation times during jumps or of phase lags while the rate forcing variables are oscillated is predicted for diffusion limited reactions and reactions with gaseous atmospheres.

15859. Heppner, R. A., Walls, F. L., Armstrong, W. T., Dunn, G. H., **Cross-section measurements for electron-H_3O^+ recombination,** *Phys. Rev. A* **13,** No. 3, 1000-1011 (Mar. 1976).

Key words: cross-section measurements; electrons; H_3O^+; ion trap; recombination.

Cross sections for electron-H_3O^+ recombination have been measured over an electron energy range of 0.060 – 1.15 eV by using a trapped-ion technique to contain an ion sample at a temperature of ≃400 K. The cross section deduced from these measurements can be represented by $\sigma=4.6\times10^{-18}\ E^{-2.9}$ cm² for $0.038<E\leq0.110$ eV; $\sigma=4.8\times10^{-16}\ E^{-0.79}$ cm² for $0.110<E\leq0.420$ eV; and $\sigma=7.5\times10^{-17}\ E^{-2.9}$ cm² for $E>0.420$ eV. Uncertainties are estimated to be at the ±50 percent level. Recombination-rate coefficients were calculated from the deduced cross sections, assuming a Maxwellian electron velocity distribution and trial forms for the cross section below 0.038 eV. Assuming the theoretical E^{-1} behavior for the cross section just above zero energy and comparing with the measured rate coefficient of Leu et al. at 540 K, we can deduce consistent cross sections below 0.038 eV to be $\sigma=6.0\times10^{-15}\ E^{-1}$ cm² for $0<E<0.23$ eV, and $\sigma=4.6\times10^{-18}\ E^{-2.9}$ cm² for $0.023<E<0.038$ eV. The calculated rate coefficients have temperature dependence $T_e^{-0.5}$ at 50 K and $T_e^{-1.13}$ at 10^5 K, and values of the coefficient are in good agreement with all direct measurements.

15860. Chen, S. T., Leep, D., Gallagher, A., **Excitation of the Sr and Sr^+ resonance lines by electron impact on Sr atoms,** *Phys. Rev. A* **13,** No. 3, 947-952 (Mar. 1976).

Key words: electron impact; strontium.

The relative optical excitation functions and polarizations of the Sr resonance line (4607 Å) and of the Sr^+ resonance lines (4078 and 4216 Å) have been measured, using crossed electron and strontium-atom beams, for electron energies from the excitation thresholds to 1497 eV. The electron-beam energy resolution was ~0.22 eV for energies below 13 eV, and the atom beam was optically thin. The excitation functions of the ionic lines were measured relative to that of the atomic resonance line at fixed energies near the maxima of the excitation functions. Using spontaneous-emission branching ratios, this yields the ratios of total excitation cross sections for the atomic and ionic resonance levels (including cascades). The Sr 5^1P excitation function has been normalized to Born theory taking account of cascade at 1497 eV, where the energy dependence of the excitation function has converged to the theoretical behavior. The resulting normalized cross sections have been compared with available theoretical calculations and other measurements. The 4607-Å polarization function is consistent with the theoretical threshold limit within experimental uncertainty.

15861. Johnson, C. R., **Hadamard's inequality for matrices with positive-definite Hermitian component,** *Michigan Math. J.* **22,** 225-228 (1975).

Key words: determinant; Hadamard's inequality; Hermitian component; positive definite.

Hadamard's inequality states that for a positive definite Hermitian matrix $A=(a_{ij})$,

$$\det A\leq a_{11}\, a_{22} \ldots a_{nn}.$$

We consider 2 parameterized subclasses of the class Π_n of matrices A for which $A+A^*>0$. In one, $|\det A| \leq a_{11} \ldots a_{nn}$ and in the other $|\det A| \geq a_{11} \ldots a_{nn}$. The former class contains the Hermitian elements of Π_n so that an alternate proof of Hadamard's inequality is provided.

15862. Newbury, D. E., Heinrich, K. F. J., Myklebust, R. L., **Errors observed in quantitative ion microprobe analysis,** (Proc. American Society for Testing and Materials Symp. on Surface Analysis Techniques for Metallurgical Applications, Cleveland, OH, Mar. 4, 1975), *Am. Soc. Test. Mater. Spec. Tech. Publ. 596,* pp. 101-113 (1976).

Key words: CARISMA program; ion microprobe mass analysis; local thermodynamic equilibrium model; quantitative analysis; secondary ion mass spectrometry; surface analysis.

Quantitative reduction of ion microprobe mass analyzer data has been performed with an empirical technique involving relative elemental sensitivity factors and with a physical model, the local thermodynamic equilibrium (LTE) model. A series of macroscopically well-characterized low alloy steels (National Bureau of Standards (NBS) Standard Reference Material 660 series) was analyzed with empirical relative sensitivity factors derived from one arbitrarily chosen alloy from the series. Relative errors of less than 50 percent were obtained in most cases, but several results were in error by 100 percent or more. The LTE model was used to analyze two multicomponent glasses. Relative errors of 200 percent were observed frequently, with some components consistently in error by an order of magnitude or more. The effect of differing reference data on LTE model calculations was tested. Different combinations of internal concentration standards and different metal/metal oxide ion ratios were

employed. The calculated concentrations showed considerable dependence on the choice of reference data.

15863. Nicodemus, F. E., **Comment on "Current definitions of reflectance,"** *J. Opt. Soc. Am. Letters* **66,** No. 3, 283-285 (Mar. 1976).

Key words: photometry; radiometry; reflectance; reflectometry.

The delta-function form of the bidirectional reflectance-distribution function (BRDF) is not limited to the case where $\theta_v=\theta_i$ and $\psi_v=\psi_i\pm\pi$ (rad), but can represent a "glint" in any direction. The conceptual advantage of the BRDF approach is briefly discussed in relation to the continuum of directional distributions actually found between the limits of purely specular "spikes" and completely diffuse reflection.

15864. Swyt, D. A., **NBS program in photomask linewidth measurements,** *Solid State Technol.* **19,** No. 4, 55-61 (Apr. 1976).

Key words: dimensional metrology; integrated circuits; linewidth measurements; microelectronics; optical microscope; photomasks; scanning electron microscope.

A problem facing the microelectronics industry is that of making accurate dimensional measurements of photomask patterns with the optical microscope, the usual tool for mask inspection. A part of the problem is the absence of calibrated linewidth standards in photomask materials for the critical 1 to 10 μm range. This article discusses the status of a National Bureau of Standards program to develop such standards and to develop the means to identify and control the parameters of optical performance which introduce errors into linewidth measurements.

15865. Cunningham, G. W., Meijer, P. H. E., **A comparison of two Monte Carlo methods for computations in statistical mechanics,** *J. Comput. Phys.* **20,** No. 1, 50-63 (Jan. 1976).

Key words: conditional probability; Ising spin; Monte Carlo method; spin system; triangular lattice.

A comparison of two Monte Carlo methods for computations in statistical mechanics is presented. In the comparison, involving a two-state problem, the transition probabilities introduced by Metropolis et al. are compared with the conditional probabilities of the Boltzmann distribution. The analytic relationship between the two is derived. Results of energy computations are given for an Ising spin system on a triangular lattice using first one set of transition probabilities, then the other. Both results are compared with the exact analytic solution. We found greater stability and faster convergence using the conditional Boltzmann probabilities. Also, some results for the Monte Carlo method in general are presented.

15866. Meijer, P. H. E., Kessler, B. V., **Heat capacity, susceptibility, and critical temperature of erbium phosphate as predicted by dipole-dipole interactions,** *Phys. Rev. B* **13,** No. 1, 255-262 (Jan. 1, 1976).

Key words: antiferromagnetism; critical temperature; dipole-dipole interaction; erbium phosphate ground state; heat capacity; lattice sums; magnetic; susceptibility.

In this paper we compute the heat capacity and susceptibility of erbium phosphate above the critical temperature, assuming that the interaction between the spins is purely dipolar. We also obtain, using the same assumption, the ground-state energy and its configuration on the basis of an extended Luttinger-Tisza calculation. From the high-temperature results we try to predict the critical temperature, using the commonly accepted idea that for long-range forces the ring diagrams (for the heat capacity) and the chain diagrams (for the susceptibility) are the dominant contributions to the series. We estimate the critical temperature to be about 0.4 K on the basis of the heat-capacity computations. This gives no information about the configuration below T_c, but we can use the results obtained via the susceptibility computations to predict that the spins lie in the x-y plane in an antiferromagnetic arrangement below T_c. These two predictions are sustained by the ground-state calculation. The estimated value for T_c obtained from the susceptibility calculation is, however, one order of magnitude larger than that derived via the heat capacity. In conclusion, we observed that the radius of convergence of the high-temperature series for dipolar interactions seems to be determined by properties other than the range of these forces.

15867. Estin, A. J., **A calculable microwave attenuation standard: The high Q cavity,** (Proc. 1972 Precision Electromagnetic Measurement Conf., Boulder, CO, June 26-28, 1972), Paper in *CPEM Digest,* pp. 28-29 (IEEE, Inc., New York, NY, June 1972).

Key words: automatic network analyzer; Q cavity; two-ports.

The high Q microwave resonant cavity is a calculable attenuation standard having a wide attenuation range and a low residual loss. It is especially well suited in calibrating computer-operated automatic network analyzers (ANA) for measurements of s_{21} of arbitrary two-ports.

Although the cavity is one of the most important classes of microwave circuit elements and is well understood, it has not been used as a substitution standard of attenuation. Excellent calculations can be made, because the model used is a close replica to the physical realization. The fact that the frequency dependence of scattering parameters is strong permits the rather novel approach of using frequency dependence, rather than mechanical displacement, as a means of setting attenuation. The relatively complicated calculations needed to achieve the dynamic range and accuracy are well handled by the on-line computer used with an ANA. Furthermore, the capability of the ANA to remove the effects of its own mismatched measuring lines when examining an arbitrary two-port is both utilized and tested by this highly reflective test standard.

15868. Julienne, P. S., Krauss, M., Stevens, W., **Collision-induced O^1D_2-$^1S_0$ emission near 5577 Å in argon,** *Chem. Phys. Lett.* **38,** No. 2, 374-381 (Mar. 1, 1976).

Key words: ab initio potentials; argon oxide; collision-induced emission; rare-gas oxide excimers.

The collision-induced emission near the 5577 Å oxygen $^1D_2-{}^1S_0$ transition in argon is investigated theoretically. Approximate ArO model potentials were constructed for the upper and lower states by adding the attractive long-range dispersion energy to the short-range repulsion calculated ab initio. The thermally averaged free–free, free–bound, and bound–bound contributions to the emission profile were calculated using the long-range quadrupole-induced dipole transition moment. The calculated bound–bound spectrum and the total emission coefficient agree well with experiment.

15869. Garner, E. L., Machlan, L. A., Barnes, I. L., **The isotopic composition of lithium, potassium, and rubidium in some Apollo 11, 12, 14, 15, and 16 samples,** (Proc. 6th Lunar Science Conf., Houston, TX, Mar. 17-21, 1975), *Geochim. Cosmochim. Acta, Suppl. 6,* **2,** 1845-1855 (Pergamon Press, New York, NY, 1975).

Key words: absolute; Apollo; composition; isotopic; lithium; potassium; relative; rocks; rubidium; soils.

The relative isotopic composition of lithium and the absolute composition of potassium and rubidium were determined in seven lunar soil and five lunar rock samples by solid sample, thermal ionization, mass spectrometry. Special precautions were taken to minimize the effect of impurities and variable sample size on the isotopic measurements. Relative to a natural reference standard of terrestrial material, the average $^6Li/^7Li$ of the lunar samples were found to be 1.0007±0.0027 (ts). The $^{85}Rb/^{87}Rb$ average value is 2.5923±0.0043. Depletions of 0.3-0.8 percent were found in the $^{39}K/^{41}K$ ratios of five soils and one rock sample. A corresponding mass-dependent increase of 0.2-0.4 percent in the $^{41}K/^{40}K$ could not be proven because the error in this measurement is approximately the same magnitude as the predicted variation. Normal potassium isotopic composition of soil 12033, removed from a 15 cm-deep trench at Head Crater, and abnormal composition of glass-coated breccia 15505 are the most significant clues to the ^{39}K depletion. Presently available data are insufficient to decipher the mechanism for potassium isotopic fractionation.

15870. Meijer, P. H. E., Scherer, W. D., **An extended lattice model of liquid helium four,** *Physica* **80A,** No. 5, 447-464 (1975).

Key words: Bogoliubov transformation; bosons; helium; lambda point; lattice model; phase transition.

A description of the low-and high-temperature behavior of liquid ^4He is given in terms of an extended Matsubara-Matsuda lattice model. Paying particular attention to the kinematical interaction and to the hard core of the bosons leads to a unified theory for the low-temperature behavior and for the lambda transition. Since the hard-core boson operators in the lattice model correspond to spin one-half operators, one can interpret the Hamiltonian as the Hamiltonian of a magnetic system of oblate form, i.e., the x-y coupling is stronger than the z coupling. A rotation introduced in the space of these operators results in a Hamiltonian consisting of three parts: One part is of the anisotropic Heisenberg form, the second contains pairs of creation-annihilation operators at different lattice sites and the third part consists of an interaction between creation-annihilation operators and the z component of the spin operators. A particular choice of the rotation angle eliminates the third part.

The equations of motion of the creation and annihilation operators are decoupled with the aid of a momentum-dependent Bogoliubov-like transformation. This leads to a linear energy spectrum and a self-consistent integral equation for the magnetization. An approximation of this self-consistency equation provides a temperature dependence of the magnetization and leads to a critical temperature for a range of external magnetic fields. It is found that in the rotated frame the angle of rotation and the magnetization exhibit a jump at the transition temperature. Consequently, the transition is of second order.

15871. Simiu, E., **Equivalent static wind loads for tall building design,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** ST4, 719-737 (Apr. 1976).

Key words: accelerations; building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind engineering; wind loads.

Certain shortcomings of current procedures for computing alongwind structural response have beeen shown to result in unrealistic estimates of tall building behavior under the action of strong winds. Differences between predictions of fluctuating response based on various such procedures have been shown to be in certain cases as high as 200 percent. The purpose of the present work is to present a procedure for calculating alongwind response, including deflections and accelerations, which incorporates these advances. The meteorological and aerodynamic models on which the procedure is based are described in brief. The practical use of the procedure is illustrated in a numerical example. Estimates are provided of errors inherent in the models employed. The range of applicability of the procedure is defined, and it is indicated that for structures with unusual modal shapes or for which the influence of higher vibration modes is significant, a recently developed computer program should be employed in lieu of the procedure presented herein.

15872. Julienne, P. S., Neumann, D., Krauss, M., **Transition moments for the $B^3\Sigma_u^- - X^3\Sigma_g^-$ and $^3\Pi_u - X^3\Sigma_g^-$ transitions in O_2,** *J. Chem. Phys.* **64,** No. 7, 2990-2996 (Apr. 1, 1976).

Key words: ab initio calculation; O_2 absorption; oscillator strength; transition moment.

Multiconfiguration self-consistent field wavefunctions are used to calculate the transition moments for the lowest dipole allowed transitions in O_2. The transition matrix element for the $B-X$ transition calculated at R_e of the ground state corresponds to an oscillator strength of 0.18, in good agreement with the experimental integrated oscillator strength 0.16 of the Schumann-Runge continuum. The $B-X$ transition moment is calculated as a function of internuclear separation. The transition matrix element to the repulsive valence $^3\Pi_u$ state calculated at R_e of the ground state corresponds to an oscillator strength of 0.003. Although the weak $^3\Pi_u$ absorption continuum is masked by the strong Schumann-Runge continuum below 1750 Å, this $^3\Pi_u$ absorption may contribute to the background continuum in the Schumann-Runge band region at low temperature.

15873. Roberts, R. W., **Materials research: A strategy to improve the performance of materials,** (Proc. of an Engineering Foundation Conf., Henniker, NH, Aug. 11-16, 1974), Paper in *Requirements for Fulfilling a National Materials Policy,* F. P. Huddle, Ed., pp. 9-17 (Office of Technology Assessment, Washington, DC, 1974).

Key words: design; development; fabrication; life cycle costing; materials policy; nondestructive evaluation; performance; processing; technical strategy.

Intelligent planning to improve the performance of materials is essential if the Nation is to continue economic growth and meet the needs of a growing population. What is required is a unified materials policy and a mechanism to carry policy and strategy through to technical completion. Five technical options will have to be exploited: materials development, processing, fabrication, design, and nondestructive evaluation. Innovations will cost money, and consumers at all levels—industry, government and the individual—will have to be educated in the concept of life cycle costing before they can be expected to accept that cost.

15874. Brinckman, F. E., Jewett, K. L., Blair, W. R., Iverson, W. P., Huey, C., **Mercury distribution in the Chesapeake Bay,** *Prog. Water Technol.* **7,** 251-252 (1974).

Key words: Chesapeake Bay; elemental sulfur; flameless atomic absorption; petroleum; plankton; sediments; total mercury; water.

Water, sediment and plankton from the Chesapeake Bay were analyzed for total mercury using flameless atomic absorption techniques. The concentrations of mercury in the sediment ranged from 0.80 to 0.02 ppm, from 4.9±0.10 ppm to 0.02±0.01 ppm in plankton and 0.00 ppb to 0.49 ppb in the water. Petroleum fractions from the sediment were found to contain 0.1 percent of mercury by weight. Elemental sulfur was found in concentrations as high as 1 percent of the sediment (dry wt.).

15875. Demkov, Y. N., **Asymptotically exact theory of electron exchange in distant collisions,** (Proc. IX Int. Conf. on the Physics of Electronic and Atomic Collisions, Seattle, WA, July 24-30, 1975), Paper in *The Physics of Electronic and Atomic Collisions*, J. S. Risley and R. Geballe, Eds., pp. 313-326 (University of Washington Press, Seattle, WA, 1976).

Key words: adiabatic collisions; charge transfer; nonresonant; potential curves; resonant; spin exchange.

The asymptotic theory of resonant charge and spin transfer is reviewed. It is shown how only the asymptotic part of the atomic wave function is important for these processes. The single electron charge transfer formula is generalized to cover the transfer of an arbitrary number of electrons. The extension to the nonadiabatic and nonresonant cases is carried out.

15876. Johnson, C. R., **Notes on nonnegative Hadamard functions,** *Linear and Multilinear Algebra* **3,** 187-192 (1975).

Key words: Hadamard product; positive semidefinite; real function.

Let f be a real valued function of a real variable and denote the r by r real matrices by $M_r(R)$. For $A_{ij} \epsilon M_m(R)$, $i, j = 1, \ldots, n$, define the Hadamard action of f on $A = (A_{ij}) \epsilon M_{mn}(R)$ by

$$(A)f = (f(\det A_{ij})).$$

This defines a map $M_{mn}(R) \xrightarrow{f} M_n(R)$. We consider a problem related to one posed by Marcus and Watkins. We call f a nonnegative Hadamard function if $(A)f$ is positive semidefinite (PSD) for all symmetric PSD matrices $A \epsilon M_{mn}(R)$.

15877. Peterson, J. R., **Sunlight photodestruction of CO_3^-, $CO_3^- \cdot H_2O$, and O_3^-: The importance of photodissociation to the *D* region electron densities at sunrise,** *J. Geophys. Res.* **81,** No. 7, 1433-1435 (Mar. 1, 1976).

Key words: CO_3^-; $CO_3^- \cdot H_2O$; *D* region; electron density; molecule; negative ion; O^-; O_3^-; photodetachment; photodissociation.

Experimental studies at photon energies between 1.8 and 2.7 eV have recently shown that photodissociation occurs well below the photodetachment threshold for CO_3^- and $CO_3^- \cdot H_2O$ and dominates the photodestruction of O_3^- at visible wavelengths. Experimental cross sections have been averaged over the solar flux spectrum to yield zero optical depth rates. Production of O^- by dissociation of CO_3^- and $CO_3^- \cdot H_2O$ and its subsequent photodetachment can probably account for the rapid increase of electron density in the *D* region of the ionosphere at sunrise. Photodissociation is also an important daytime loss mechanism for CO_3^- and its hydrate in the 50- to 80-km region.

15878. Parrish, W. R., **Recovery of hydrogen liquefaction energy,** *Proc. 10th Conf. on Intersociety Energy Conversion Engineering, Newark, DE, Aug. 18-22, 1975, IECEC 1975 RECORD, IEEE Catalog No. 75CHO 983-7TAB*, pp. 1352-1355 (1975).

Key words: air separation; electrical power generation; energy recovery; hydrogen; liquefaction energy.

Liquid storage is an attractive means for storing the large quantities of synthetic hydrogen that will be needed in the future. However, the actual energy required for liquefaction is roughly 30 percent of hydrogen's lower heating value. This paper considers some ways of recovering part of the liquefaction energy. The emphasis is on utility applications. Results show that it is technically feasible to recover 25 to 50 percent of the actual liquefaction energy if a MHD generator is used; recovery factors of approximately 18 percent could be obtained with gas turbines, and lower recovery factors of 8 to 20 percent are possible if fuel cells are used. This energy recovery has the net effect of lowering the required liquefaction energy which makes liquid a more attractive means of storage.

15879. Voth, R. O., Daney, D. E., **H_2 liquefaction: Effects of component efficiencies,** *Proc. 10th Conf. on Intersociety Energy Conversion Engineering, Newark, DE, Aug. 18-22, 1975, IECEC 1975 RECORD, IEEE Catalog No. 75CHO 983-7TAB*, pp. 1356-1362 (1975).

Key words: compressor efficiency; cycle efficiency; heat exchanger losses; hydrogen liquefier; pressure drop losses.

Liquid hydrogen has been proposed as a synthetic fuel to be used as an "energy carrier" to replace fossil fuels in certain applications. The cost of liquid hydrogen is dependent on the cost of gaseous hydrogen plus a cost for liquefaction. The liquefaction costs are a function of the efficiency of the hydrogen liquefier.

Efficiencies of current large liquefiers are approximately 30 percent of Carnot. Although the Carnot cycle work is a good basis for comparing the efficiencies of various refrigerators and liquefiers operating at different temperature levels, the Carnot cycle is not amenable to showing the maximum efficiency for a hydrogen liquefier using practical components. In this paper an alternate cycle is defined that permits evaluation of overall cycle efficiency using 1) practical components with variable efficiencies, 2) variable heat exchanger temperature differences, and 3) variable system pressure drop. The resulting cycle efficiencies will serve as a guide to engineers performing thermodynamic cycle studies to improve the efficiencies of hydrogen liquefiers and will help define the maximum attainable efficiency for future liquefiers.

15880. Fatiadi, A. J., **Active manganese dioxide oxidation in organic chemistry—Part 1,** *Synthesis Reviews*, No. 2, 65-104 (Feb. 1976).

Key words: active; manganese dioxide; organic chemistry; oxidation; reagent; review.

Active Manganese dioxide and its various modifications provide a reagent of choice for a mild, selective (heterogeneous) oxidation of diverse classes of organic compounds. The aim of the present review is to discuss the highlights of the synthetic applications of active manganese dioxide, and to show its selectivity and specificity as an oxidant, as a dehydrogenation reagent, as a coupling reagent, and as a selective, analytical tool in the structure determination of complex, organic molecules derived from natural products. The review also includes a discussion of the mechanism of action and the complexity of the heterogeneous reactions.

15881. Tsang, W., **Comparison between experimental and calculated results on the decomposition of chemically activated alcohols,** *Int. J. Chem. Kinet.* **VIII,** 193-203 (1976).

Key words: alcohols; chemical activation; nonequilibrium; oxygen atoms; RRKM; thermal decomposition.

The life times of chemically activated alcohols have been determined using the high-pressure unimolecular rate parameters for thermal decomposition of alcohols from shock-tube studies and RRKM calculations. They are compared with literature numbers (from insertion of $O(^1D)$ into hydrocarbons). It is suggested that in some cases singlet oxygen carries excess energy into the hydrocarbon. The consequences of such an assumption are explored and discrepancies with previously published conclusions discussed.

15882. Achenbach, P. R., **Government activities and regulations**

for buildings on energy saving standards. A look at what various agencies have done and intend to do for energy conservation, *Heat./Piping/Air Cond.* **47,** No. 13, 41-46 (Dec. 1975).

Key words: energy consumption in NYC schools; energy-saving opportunities; incentives—educational, persuasive, financial, regulatory; modular boiler study; NBS-campus energy retrofit; retrofitting existing buildings.

The major near-term opportunity for energy conservation in buildings occurs in the existing building inventory, which includes some 70-million residential and several million commercial and institutional buildings, constructed before energy conservation was a recognized national need. This paper identifies 1) existing documents relating to retrofit, and 2) documents in development for both new and extant buildings with potential impact on regulations, standards, and codes, if the energy shortage persists.

Federal and State government incentives for building owners or operators to work for energy conservation are broadly classified as *educational*—seminars, conferences, publications with wide dissemination for use as guidelines; *persuasive*—exhortation by government and community leaders, and commercial sales efforts toward modification of present buildings or inclusion of energy-efficient components in new buildings; *regulatory*—standards, specifications, regulations and codes—voluntary and mandatory; and *financial*—tax breaks, low-interest loans, direct subsidy, etc. The paper lists documents now available and some in progress, and cites ongoing studies with potential large impact on the Nation's energy conservation effort. The latter include a retrofit of selected NBS laboratories for energy conservation and comparison; a study of existing New York City school buildings for energy consumption; a demonstration of energy savings in a 20-yr-old frame house by sealing leaks, installing storm windows and insulation; and a study of modular boilers which indicates that using several equal-capacity boilers to service a load in lieu of a single large boiler enables operators to match the load under varying weather conditions, and could lead to an approximate 10 percent saving during a typical winter heating season.

15883. Bardsley, J. N., **Theory of low-energy electron-atom collisions and related processes,** (Proc. IX Int. Conf. on the Physics of Electronic and Atomic Collisions, Seattle, WA, July 24-30, 1975), Paper in *The Physics of Electronic and Atomic Collisions,* J. S. Risley and R. Geballe, Eds., pp. 151-157 (University of Washington Press, Seattle, WA, 1976).

Key words: atom; collisions; electron; low energy; review; scattering; theory.

Imaginative new approaches to the theoretical treatment of low-energy electron-atom collisions are being proposed and tested by investigations. This paper reviews current activity, citing successes and problem areas, giving a characterization of the status of the field and suggesting where further progress is needed.

15884. Read, F. H., **Energy exchanges between two escaping electrons,** (Proc. IX Int. Conf. on the Physics of Electronic and Atomic Collisions, Seattle, WA, July 24-30, 1975), Paper in *The Physics of Electronic and Atomic Collisions,* J. S. Risley and R. Geballe, Eds., pp. 176-193 (University of Washington Press, Seattle, WA, 1976).

Key words: atom; collision; Coulomb-interaction; electron; energy exchange; ionization; threshold.

The final-state Coulomb interaction between three or more outgoing charged particles from a reaction can cause exchanges of energy and angular momentum between them. Such exchanges may be present for example when the reaction products consist of two electrons receding from a positive ion. The experimental evidence for the existence of such effects in threshold ionization and threshold autoionization are reviewed, and their possible theoretical descriptions are discussed.

15885. Holt, H. K., **Resonance trapping at low pressures,** *Phys. Rev. A* **13,** No. 4, 1442-1447 (Apr. 1976).

Key words: lifetime measurement; low pressure; resonance trapping.

When a small volume of atoms within a larger one is excited by a short pulse of electrons or light, the apparent lifetime of the decaying atoms is increased by the resonance trapping in the surrounding gas. In this paper the apparent lifetime is calculated for two different geometries and line shapes, and the result of having more than one lower level is presented.

15886. Linsky, J. L., **And who will analyze the data?,** *Astrophys. Lett. Editorial* **17,** 1-2 (1976).

Key words: astronomy; manpower problems.

This invited Guest Editorial discusses the manpower problem in astronomy and the urgent need for qualified new people to analyze forthcoming important data.

15887. Layer, H. P., Deslattes, R. D., Schweitzer, W. G., Jr., **Laser wavelength comparison by high resolution interferometry,** *Appl. Opt.* **15,** No. 3, 734-743 (Mar. 1976).

Key words: interferometer; laser; optical frequency; optical heterodyne; wavelength comparison.

High resolution interferometry has been used to determine the wavelength ratio between two molecularly stabilized He-Ne lasers, one locked to a methane absorption at 3.39 μm and the other locked to the k peak of $^{129}I_2$ at 633 nm. An optical beat frequency technique gave fractional orders while a microwave sideband method yielded the integer parts. Conventional (third derivative) peak seeking servoes stabilized both laser and cavity lengths. Reproducibility of the electronic control system and optics was a few parts in 10^{12}, while systematic errors associated with curvature of the cavity mirrors limited the accuracy of the wavelength ratio measurement to 2 parts in 10^{10}. The measured wavelength ratio of the methane stabilized He-Ne laser at 3.39 μm [$P(7)$ line, ν_3 band] to the $^{129}I_2$ (k peak) stabilized He-Ne laser 633 nm was 5.359 049 260 6 (0.0002 ppm). This ratio agrees with that calculated from the (lower accuracy) results of earlier wavelength measurements made relative to the ^{86}Kr standard. Its higher accuracy thus permits a provisional extension of the frequency scale based on the cesium oscillator into the visible spectrum.

15888. McGuire, B. J., Jr., **The Department of Commerce energy labeling and energy efficiency programs for household appliances,** *Proc. National Agricultural Outlook Conf., Washington, D.C., Nov. 17-20, 1975,* pp. 369-377 (U.S. Department of Agriculture, Washington, DC, Dec. 18, 1975).

Key words: combination refrigerator-freezers; consumer information; efficiency; energy labeling; room air conditioners; water heaters.

The development and present status of the Department of Commerce energy labeling and energy efficiency programs are described. Labels for room air conditioners, combination refrigerator-freezers, and water heaters are discussed in detail. Energy reduction goals under the energy efficiency programs are given. The possible effect of pending legislation is described.

15889. Paulsen, P. J., Alvarez, R., Mueller, C. W., **Trace element determinations in a low-alloy steel standard reference material by isotope dilution, spark source mass spectrometry,** *Appl. Spectrosc.* **30,** No. 1, 42-46 (1976).

Key words: isotope dilution; NBS Standard Reference Material; preconcentration; spark source mass spectrometry; steel; trace elements.

A stable isotope dilution procedure using the spark source mass spectrograph was developed for the simultaneous determination of cerium, copper, neodymium, selenium, silver, tellurium, and zirconium in a low-alloy steel material. Except for copper, the elements were present at trace concentrations that are difficult to determine by most analytical methods. In the procedure, known amounts of the isotopically enriched elements were added to 100-mg samples, which were dissolved in perchloric and hydrofluoric acids. After evaporation of the solutions almost to dryness, dissolution of the residues, and addition of hydrofluoric acid to complex the iron, the resulting solutions were electrolyzed in polytetrafluoroethylene cells. The electrodeposit on high purity, gold cathode wires was sparked in the mass spectrograph and the isotope ratios of the isotopically equilibrated elements were measured. The concentrations, ranging from 0.041 percent for copper to 3.1 μg/g (ppm) for neodymium, were calculated from the general isotope dilution equation. The low-alloy steel is available from NBS as Standard Reference Material 1261.

15890. Achenbach, P. R., **Government participation in safety standards for refrigerating and air conditioning equipment,** (Proc. Symp. on Domestic Refrigerator and Room Air Conditioners—Safety Standards and Service, Lake Placid, NY, June 24-26, 1968), *ASHRAE Special Bull.* **LP 68-3,** 8-12 (1968).

Key words: Government participation; refrigeration safety standards; safety of appliances; standards for safety.

Consumer protection against equipment hazards can be broadly categorized into three areas: hazard to health, hazard to life, and hazard to property. The principal instrumentalities through which safety requirements are brought into general use are: 1) state, municipal and model national codes, 2) national, international, mandatory and association standards, and 3) procurement specifications. The manufacturers of refrigerators, freezers, and air conditioners have, in general, provided the organizational leadership in preparing, sponsoring, and revising safety standards in the United States. However, agencies of the Federal Government are active in most national standards organizations concerned with equipment safety, and frequently conduct research on materials, systems, and equipment to develop technical information on safety for use in codes, standards, and specifications. Several specific investigations of refrigerators, freezers, and water coolers are described briefly to illustrate the kinds of hazards that may occur from choice of materials, design of a system, or manner of use by the owner.

15891. Smith, S. J., **Coherent electron impact excitation of different L states in the n=3 shell of atomic hydrogen,** (Proc. Int. Symp. on Electron and Photon Interactions with Atoms, Stirling, Scotland, July 16-19, 1974), Chapter in *Electron and Photon Interactions with Atoms,* H. Kleinpoppen and M. R. C. McDowell, Eds., pp. 365-374 (Plenum Publishing Corp., New York, NY, 1976).

Key words: atomic hydrogen; Balmer alpha; beam foil; crossed beams; electrons; excitation; optical spectroscopy; Stark effect.

An interpretation of a measurement by Mahan, Gallagher, and Smith of the Balmer-α intensity excited by electron impact on a diffuse atomic hydrogen beam in an external electric field, is presented. An asymmetry in the Balmer-α intensity perpendicular to the electron beam, as a function of the *direction* of an electric field parallel (or anti-parallel) to the electron beam axis, is discussed in terms of displacement of the electron charge cloud during the collision, an interpretation which is also applicable to some recent results of beam foil spectroscopy.

15892. Lin, S. L., Bardsley, J. N., **Computation of speed distributions for ions in drift tubes,** *J. Phys. B Letter to the Editor* **8,** No. 17, L461-L464 (1975).

Key words: drift tubes; velocity distributions.

The speed distribution of O^+ ions drifting through helium gas under the influence of an electric field is computed by a Monte Carlo simulation. The average energy agrees with previous analytic estimates, but the distributions differ significantly from those observed in a recent experiment. The distributions show considerable distortion from the Maxwell-Boltzmann shape.

15893. Geltman, S., **Excitation and ionization in the Coulomb-projected Born approximation,** (Proc. Int. Symp. on Electron and Photon Interactions with Atoms, Stirling, Scotland, July 16-19, 1974), Chapter in *Electron and Photon Interactions with Atoms,* H. Kleinpoppen and M. R. C. McDowell, Eds., pp. 387-396 (Plenum Publishing Corp., New York, NY, 1976).

Key words: collisions; electron; excitation; hydrogen; ionization; theoretical.

In this progress report we will describe the physical basis of the Coulomb-projected Born method, discuss the similarities and differences of its predictions with those of the usual Born approximation, and compare with available experimental data.

15894. Epstein, M. S., Rains, T. C., **Evaluation of a xenon-mercury arc lamp for background correction in atomic absorption spectrometry,** *Anal. Chem.* **48,** No. 3, 528-531 (Mar. 1976).

Key words: arsenic; atomic absorption; atomic spectrometry; background, correction; nonflame, atomization; stray light; xenon-mercury, arc lamp.

The use of a xenon-mercury arc lamp for background correction in atomic absorption spectrometry is evaluated. The high spectral irradiance of this lamp permits background correction to be extended much further into the visible region of the spectrum than previously possible with hydrogen or deuterium continuum sources. The application of the lamp for background correction using a graphite furnace atomizer is demonstrated.

15895. Tighe, N. J., **Experimental techniques,** Chapter in *Electron Microscopy in Mineralogy,* H. R. Wenk et al., Eds., pp. 144-171 (Springer-Verlag Berlin Heidelberg, Germany, 1976).

Key words: electron microscopy; *in situ* experiments; ionic bombardment; microscope stages; rock-forming minerals; specimen preparation.

The paper describes cleavage, ionic bombardment, and chemical dissolution techniques for preparing specimens for transmission electron microscopy. Special stages used for tilting, heating, and environmental experiments are described.

15896. Eckerle, K. L., Venable, W. H., Jr., Weidner, V. R., **Averaging sphere for ultraviolet, visible, and near infrared wavelengths: A highly effective design,** *Appl. Opt.* **15,** No. 3, 703-707 (Mar. 1976).

Key words: averaging sphere; efficiency; radiometry; spectrophotometry; sphere coatings.

Through the use of an efficient design and a newly available sphere coating material, a simple, passive, sturdy averaging sphere was made that operates effectively over the wavelength range from 200 nm to 2000 nm. Data are reported for a sphere of this type in which the sphere transmittance is 0.32 at 200 nm and rises rapidly to near the maximum theoretical value of 0.56 over the remainder of the wavelength range. The several orders of magnitude reduction in error due to beam displacement more than compensate the slight reduction in signal for many spectrophotometric and radiometric applications.

15897. Iverson, W. P., Huey, C., Brinckman, F. E., Jewett, K. L., Blair, W., **Biological and nonbiological transformations of mercury in aquatic systems,** *Prog. Water Technol.* **7,** 193-195 (1974).

Key words: bacteria; elemental mercury; flameless atomic absorption spectroscopy; laser Raman spectroscopy; nuclear magnetic resonance spectroscopy; phenylmercuric acetate; volatilization.

Nine phenylmercuric acetate-tolerant bacterial strains, isolated from the Chesapeake Bay were found to produce metallic mercury from phenylmercuric acetate using a flameless atomic absorption spectrophotometer on-line with a bioreactor. Tolerance levels of one *Pseudomonas* strain to 10 metal ions were reported. Nonbiological methylation of a number of aquated methylated metal cations were studied using nuclear magnetic resonance and laser Raman spectroscopy.

15898. Evenson, K. M., Petersen, F. R., **Laser frequency measurements, the speed of light, and the meter,** Paper in *Topics in Applied Physics* **2,** H. Walther, Ed., pp. 349-368 (Springer-Verlag Berlin Heidelberg, Germany, 1976).

Key words: c; laser; laser frequency measurement; length standard saturated absorption stabilization; speed of light.

The extension of absolute frequency measuring techniques to the infrared (3.4 μm) has been made possible with the development of the tungsten-nickel point contact diode. Saturated absorption stabilized lasers now provide sources sufficiently stable to demand the resolution and accuracy of direct frequency measurement techniques.

The product of the measured frequency and wavelength of an 88 THz methane stabilized He-Ne laser yields a value of the speed of light 100 times more accurate than the previously accepted value.

Stabilized lasers are excellent wavelength sources which may be used in redefining the meter. In fact, direct frequency measurements now make it possible to redefine the meter so as to fix the value of c!

15899. Simiu, E., Patel, V. C., Nash, J. F., **Mean speed profiles of hurricane winds,** *J. Eng. Mech. Div. Proc. Am. Soc. Civil Eng.* **102,** EM2, 265-273 (Apr. 1976).

Key words: boundary layer; hurricanes; loads (forces); natural analysis; tall buildings; wind profiles.

A numerical solution of the hurricane boundary layer problem is presented in which the hurricane is modeled as a steady, axisymmetric, neutrally stratified flow. The turbulence effects in the flow are accounted for by the phenomenological relations proposed by Bradshaw et al., and Nash, which provide a considerably more realistic picture of the actual flow than the pseudolaminar model used in previous solutions of the boundary layer problem. The results of the calculations obtained on the basis of the model just described suggest that: (1) in the height range of interest to the structural designer, say up to a height of 400 m above ground, it is permissible to use the logarithmic law to represent the mean velocity profile of hurricane winds and (2) if the relation between wind speeds in different roughness regimes which obtains in extratropical storms is applied to hurricane winds, the speeds over built-up terrain, calculated as functions of speed over open terrain, may be underestimated by about 10 percent and 10-20 percent in suburban and in urban exposure, respectively. The corresponding mean loads are then underestimated by about 15 and 30 percent, respectively.

15900. Kessler, J., **Recent advances in polarized-electron experiments,** (Proc. IX Int. Conf. on the Physics of Electronic and Atomic Collisions, Seattle, WA, July 24-30, 1975). Paper in *The Physics of Electronic and Atomic Collisions,* J. S. Risley and R. Geballe, Eds., pp. 112-125 (University of Washington Press, Seattle, WA, 1976).

Key words: electron; experiment; LEED; multi-photon; photoionization; review; scattering; spin-polarization.

Recent experimental progress on collisional and radiative processes involving electron-spin polarization is reviewed. The various processes of this type are summarized. The review includes discussion of work carried out in several laboratories on polarization effects in scattering by free atoms, in scattering by surfaces (LEED), in single- and multi-photon ionization, of atoms as well as in photoelectron emission from certain solid surfaces.

15901. Hagan, L., **Reports of observatories for 1974/75, National Bureau of Standards, Washington, DC,** *Bull. Am. Astron. Soc.* **8,** No. 1, 210-214 (1976).

Key words: atomic energy levels; atomic line shapes; atomic spectra; atomic transition probabilities; bands, molecular; energy levels, atomic; line shapes, atomic; molecular bands; molecular spectra; rotational constants.

Research at the National Bureau of Standards in spectroscopy pertinent to astronomy is summarized. Publications on atomic spectra, atomic transition probabilities and line broadening, and molecular spectra are referenced and work in progress is discussed.

15902. Fatiadi, A. J., **Active manganese dioxide oxidation in organic chemistry—Part II,** *Synthesis Reviews,* No. 3, 133-167 (Mar. 1976).

Key words: active; chemistry; dioxide; heterogeneous; manganese; organic; oxidation.

A review is given of reactions in which active manganese dioxide and its various modifications provide a reagent of choice for a mild, selective, heterogeneous oxidation of diverse classes of organic compounds. Applications of manganese dioxide as a dehydrogenation reagent, a coupling reagent, and as an analytical tool are also discussed. This survey includes 697 references.

15903. Cetas, T. C., **A magnetic temperature scale from 1 to 83 K,** *Metrologia* **12,** 27-40 (1976).

Key words: ac-dc resistance thermometry; ac susceptibility; gadolinium sulphate; germanium resistance thermometers; IPTS-68; low temperature scales, 1-83 K; magnetic thermometer; manganous ammonium sulphate; paramagnetic salts; platinum resistance thermometers.

The low frequency (30 Hz) paramagnetic susceptibilities of powdered samples of gadolinium sulphate octahydrate and manganous ammonium sulphate hexahydrate have been measured from 1 to 83 K in order to test the thermodynamic consistency of the International Practical Temperature Scale of 1968 (IPTS-68). The data can be characterized by a physically based expression with essentially two constants as opposed to the twenty-one

terms of the IPTS-68 Reference Function for the range 13.81 to 273.15 K. Variations in the IPTS-68 of up to ±3 mK about the smooth magnetic scale are found and the 20.28 K (e-H_2 b.p.) fixed point is shown to be inconsistent with the other fixed points by about +3 mK. The data also provide a means of thermodynamically extrapolating the IPTS-68 to lower temperatures where comparisons are made with other recent data. The reproducibility of the data is ±0.5 mK below 50 K and ±1 mK up to 83 K, while the total estimated measurement uncertainties are from one to three times greater.

15904. Tsang, W., **Thermal stability of alcohols,** *Int. J. Chem. Kinet.* **VIII,** 173-192 (1976).

Key words: alcohols; heats of formation; hydroxy-alkyl radicals; shock tube; thermal decomposition; 2,3-dimethylbutanol-2; 3,3-dimethylbutanol-2.

3,3-Dimethylbutanol-2 (3,3-DMB-ol-2) and 2,3-dimethylbutanol-2 (2,3-DMB-ol-2) have been decomposed in comparative-rate single-pulse shock-tube experiments. The mechanisms of the decompositions are

$$\text{2,3-DMB-ol-2} \xrightarrow{k_B} i\text{C}_3\text{H}_7\cdot + \cdot\text{C(CH}_3)_2\text{OH}$$

$$\xrightarrow{k_{EP}} \text{H}_2\text{O} + \text{H}_2\text{C}{-}\text{C(CH}_3){-}\text{CH(CH}_3)_2 \text{ (2,3-DMB-l)}$$

$$\text{3,3-DMB-ol-3} \xrightarrow{k_{ET}} t\text{C}_4\text{H}_9\cdot + \cdot\text{CH(CH}_3)\text{OH}$$

$$\xrightarrow{k_B} \text{H}_2\text{O} + (\text{CH}_3)_2\text{C}{-}\text{C(CH}_3)_2$$

$$\xrightarrow{k_{EP}} \text{H}_2\text{O} + \text{H}_2\text{C}{-}\text{C(CH}_3)_3 \text{ (3,3-DMB-l)}$$

The rate expressions are

$$k_B(\text{2,3-DMB-ol-2}) = 10^{16.24} \exp(-37{,}400/T) \text{ sec}^{-1}$$

$$k_{EP}(\text{2,3-DMB-ol-2}) = 10^{14.17} \exp(-32{,}300/T) \text{ sec}^{-1}$$

$$k_{ET}(\text{2,3-DMB-ol-2}) = 10^{13.66} \exp(-32{,}700/T) \text{ sec}^{-1}$$

$$k_B(\text{3,3-DMB-ol-2}) = 10^{16.33} \exp(-37{,}500/T) \text{ sec}^{-1}$$

$$k_{EP}(\text{3,3-DMB-ol-2}) < 10^{14.0} \exp(-34{,}200/T) \text{ sec}^{-1}$$

They lead to $D(i\text{C}_3\text{H}_7\text{—H}) - D((\text{CH}_3)_2(\text{OH})\,\text{C—H}) = 8.3$ kJ and $D(\text{C}_2\text{H}_5\text{—H}) - D(\text{CH}_3(\text{OH})\,\text{CH—H}) = 24.2$ kJ.

These data, in conjunction with reasonable assumptions, give

$$k(t\text{C}_4\text{H}_9\text{OH} \rightarrow \text{CH}_3\cdot + \cdot\text{C(CH}_3)_2\text{OH}) = 10^{16.8} \exp(-40{,}900/T) \text{ sec}^{-1}$$

$$k(i\text{C}_3\text{H}_7\text{OH} \rightarrow \text{CH}_3\cdot + \cdot\text{CH(CH}_3)\text{OH}) = 10^{16.5} \exp(-41{,}100/T) \text{ sec}^{-1}$$

$$k(n\text{C}_3\text{H}_7\text{OH} \rightarrow \text{CH}_3\cdot + \cdot\text{CH}_2\text{CH}_2\text{OH}) = 10^{16.2} \exp(-41{,}100/T) \text{ sec}^{-1}$$

$$k(\text{C}_2\text{H}_5\text{OH} \rightarrow \text{CH}_3\cdot + \cdot\text{CH}_2\text{OH}) = 10^{16.4} \exp(-42{,}500/T) \text{ sec}^{-1}$$

and

$$D(\text{CH}_3\text{—H}) - D(\text{CH}_2\text{OH—H}) = 36.8 \text{ kJ}$$

The rate expressions for the decomposition of 2,3-DMB-l and 3,3-DMB-l are

$$k(\text{2,3-DMB-l} \rightarrow \text{CH}_3\cdot + \text{H}_2\text{C}{-}\text{C(CH}_3) - \dot{\text{C}}\text{H(CH}_3)) = 10^{16.0} \exp(-35{,}700/T) \text{ sec}^{-1}$$

and

$$k(\text{3,3-DMB-l} \rightarrow \text{CH}_3\cdot + \text{H}_2\text{C}{-}\text{CH} - \dot{\text{C}}(\text{CH}_3)_2) = 10^{16.2} \exp(-35{,}500/T) \text{ sec}^{-1}$$

15905. Snyder, J. J., Hall, J. L., **A new measurement of the relativistic Doppler shift,** (Proc. 2nd Int. Conf. on Laser Spectroscopy, Megève, France, June 1975), Paper in *Laser Spectroscopy,* S. Haroche, J. C. Pebay-Peyroula, T. W. Hansch, and S. E. Harris, Eds., No. 43, 6-17 (Springer-Verlag, Berlin, Germany, 1975).

Key words: accelerated atom beam; experimental relativity; laser spectroscopy; laser stabilization; saturated absorption.

Saturated absorption laser spectroscopy allows, in principle, the study of atomic absorption lines free from first-order Doppler effects. However, the second-order Doppler effect is not suppressed, as it is a manifestation of the time dilation of special relativity. We describe an experiment using a stabilized visible cw dye laser to study the absorption of metastable neon atoms moving at high speed transversely to the laser beam. The dye laser has been stabilized to about 50 kHz absolute, considering linewidth as well as frequency jitter and drift. In these prototype experiments the neon metastable atoms are produced by charge transfer in Na vapor from an accelerated beam ($\approx \mu$A) of Ne^+ ($E \leq 50$ keV). The observed time dilation effect is in agreement with the predictions of special relativity at the 1/2 percent noise level of the first preliminary experiment. A factor 30 to 100 improvement is expected with direct improvement of our experimental techniques. Still larger improvements may be possible with higher acceleration voltages where residual first-order errors become fractionally smaller.

15906. Kleimann, R. E., Eicke, W. G., Jr., **An automated standard cell comparator controlled by a desk calculator: A preliminary report,** *Proc. 1975 ASSC Conf. Record on Automated Support Systems, Westbury, Long Island, NY, Oct. 28-30, 1975,* pp. 18-23 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1975).

Key words: automated; calculator; calibration; crossbar switch; low-level voltage measurements; MIDAS; programmable desk calculator; standard cell comparator.

A system is described with which measurements of standard cell differences can be made automatically to an accuracy of one part in 10^7. The system is built using all commercially available equipment and is designed to be a relatively inexpensive easy-to-use instrument for the calibration laboratory. The system is designed around a BASIC-programmable desk calculator and MIDAS, an NBS-developed modular interface, which together control the necessary switching, stimuli and measurements for a set of standard cell difference measurements. The calculator then processes the measurement data using a least-squares fit and prints a calibration report for the cells. The design and construction of the system is described along with an evaluation of the results obtained with the system.

15907. Caswell, R. S., Goodman, L. J., Colvett, R. D., **International intercomparison of neutron dosimetry,** (Proc. 5th Int. Congress of Radiation Research, Seattle, WA, July 14-20, 1974), Paper in *Radiation Research,* R. F. Oddvard, F. Nygaard, H. J. Adler, and W. K. Sinclair, pp. 532-546 (Academic Press, Inc., New York, NY, 1975).

Key words: international intercomparison; neutron dosimetry.

An International Neutron Dosimetry Intercomparison (INDI) has been carried out at the Radiological Research Accelerator Facility (RARAF) at Brookhaven National Laboratory

under the sponsorship of the International Commission on Radiation Units and Measurements. The objective was to compare results obtained by different groups performing fast neutron dosimetry in situations approximating those generally encountered in radiotherapy and radiobiology. Fourteen groups from six countries participated. Intercomparison energies for tissue kerma in free air were 15.5, 5.5, 2.1, and 0.67 MeV and ^{252}Cf fission neutron spectrum. In addition, depth dose measurements in a phantom were made at the two highest energies. The experimental arrangements will be described, and preliminary results of the intercomparison given.

15908. Smith, C. E., Jacox, M. E., Milligan, D. E., **The absorption and fluorescence spectra of matrix-isolated CF_2,** *J. Mol. Spectrosc.* **60,** 381-387 (1976).

Key words: absorption spectrum; band experiment; CF_2; CH_2F_2 photolysis; fluorescence spectrum; matrix isolation.

The CF_2 absorption spectrum between 2700 and 2250 Å and its fluorescence spectrum excited by radiation near 2500 Å have been observed in matrix isolation experiments. The positions of the absorption bands are somewhat dependent on the environment in which the CF_2 molecule is trapped. The absorption spectrum can be explained in terms of a progression in the upper-state bending fundamental, with a band spacing of 499 cm^{-1}, and the fluorescence spectrum involves a progression in the ground-state bending fundamental, with a band spacing of 657 cm^{-1}. A significant deviation between the calculated and observed separation of any given absorption and emission band can be explained by considering the effect of phonon interactions. Arguments are presented suggesting that the band origin lies near 36 900 cm^{-1} for CF_2 produced by the photolysis of CF_2N_2 in an argon matrix.

15909. Mandel, J., **Models, transformations of scale, and weighting,** *J. Qual. Technol.* **8,** No. 2, 86-97 (Apr. 1976).

Key words: interlaboratory comparisons; invariance; models; precision; precision of measurement; repeatability; reproducibility; test methods; transformations; weighting.

A realistic model as an indispensable prerequisite to any meaningful data analysis. Since most common statistical procedures are based on models involving specific assumptions, such as homoscedasticity or absence of certain interactions, it has become current practice to transform the scale of the data in the hope of achieving conformance with these assumptions. It is suggested in this paper that this approach is logically unsatisfactory. The conclusions drawn from a meaningful analysis should be essentially invariant with respect to scale transformations. The model should be flexible enough to allow for a realistic representation of the physical reality underlying the data. Heteroscedasticity should be dealt with by means of statistical weighting, and interactions, rather than being "assumed away," must be part of the model.

The proposed approach is shown to satisfy these requirements and is illustrated in terms of two individual studies. One is an interlaboratory evaluation of a physical test procedure and the other one deals with the within- and between-laboratory precision of a method of chemical analysis.

15910. Carlsten, J. L., Szöke, A., **Spectral resolution of near-resonant Rayleigh scattering and collision-induced resonance fluorescence,** *Phys. Rev. Lett.* **36,** No. 12, 667-671 (Mar. 22, 1976).

Key words: collisions; laser-excited fluorescence; Rayleigh scattering.

Light scattered from strontium vapor near its 460.73-nm ($^1P_1^\circ - {}^1S_0$) resonance transition was resolved into its three spectral components: Rayleigh scattering, collision-induced fluorescence, and three-photon scattering. The saturation behavior of the central (Rayleigh) component and the intensity and ac Stark shift of the three-photon component were studied as a function of detuning and laser intensity. Good agreement is obtained with theoretical predictions.

15911. McClintock, W., Henry, R. C., Moos, H. W., Linsky, J. L., **Ultraviolet observations of cool stars. V. The local density of interstellar matter,** *Astrophys. J.* **204,** No. 2, L103-L106 (Mar. 1, 1976).

Key words: interstellar matter; line profiles; stars, late type.

A high-resolution *Copernicus* observation of the chromospheric Lα emission line of the nearby (3.3 pc) K dwarf ϵ Eri sets limits on the velocity, the velocity dispersion, and the density n_H of atomic hydrogen in the local interstellar medium. Analysis shows that the interstellar Lα absorption is on the flat portion of the curve of growth. An upper limit of n_H=0.12 cm^{-3} is derived. The value of n_H is 0.08±0.04 cm^{-3} if the velocity dispersion parameter b=9 km s^{-1}, corresponding to a temperature of 5000 K. Also, the interstellar deuterium Lα line may be present in the spectrum.

15912. Smith, A. J., Read, F. H., Imhof, R. E., **Measurement of the lifetimes of ionic excited states using the inelastic electron-photon delayed coincidence technique,** *J. Phys. B* **8,** No. 17, 2869-2879 (Dec. 1975).

Key words: CO^+; CO_2^+; coincidence; electron impact; ions; lifetime; molecule; N_2^+; radiative; transition probability.

A modification of the inelastic electron-photon delayed coincidence technique is described which permits the measurement of the lifetimes of ionic excited states. The technique has been applied to measurements in the N_2^+, CO^+ and CO_2^+ ions, and the essential results are as follows: N_2^+ $B^2\Sigma_u^+$, v=0 60.6±0.6 ns; CO^+ $B^2\Sigma^+$ 54.3±1.8 ns; CO_2^+ $\tilde{A}^2\Pi_u$ 108.3±1.4 ns; CO_2^+ $\tilde{B}^2\Sigma_u^+$ 117.4±2.1 ns. Also presented are two coincidence energy-loss spectra of the continua resulting from the excitation of the $\tilde{A}^2\Pi_u$ and $B^2\Sigma_u^+$ states respectively of CO_2^+.

15913. Brunt, J. N. H., Read, F. H., **Aberrations in electrostatic lenses,** *J. Phys. E* **8,** No. 12, 1015-1020 (Dec. 1975).

Key words: aberration; electron optics; electron scattering; electrostatic lens; image; low energy.

The approximation of using third order spherical aberration coefficients to represent the combined effects of all the third order aberrations of electrostatic lenses is investigated. For the types of lenses and the object and image conditions often existing in low energy electron scattering experiments the inaccuracy in using this approximation to give an upper limit to the increases in image sizes is of the order of 20 percent.

15914. Bennett, H. S., Forman, R. A., **Absorption coefficients of weakly absorbing solids: Theory of a barothermal gas cell,** *Appl. Opt.* **15,** No. 2, 347-352 (Feb. 1976).

Key words: absorption coefficients; barothermal gas cell; gas pressure; highly transparent solids; thermal conduction.

For the case in which a laser beam passes through the weakly absorbing windows of a cell containing a nonabsorbing gas, the temperature profiles in the cell windows and the pressure and temperature profiles in the gas have been calculated. Both the transient response and steady-state behavior of the cell are examined when the barothermal conditions are valid. These calcu-

lations suggest that sufficient heat transfers by thermal conduction from the weakly absorbing windows into the gas to produce a measurable pressure rise in the gas. The theory contains the two assumptions that bulk absorption in the window is the mechanism by which energy is transferred from the laser beam to the windows and that the window and adjacent gas are in good thermal contact. Numerical examples for a laser glass and air (nitrogen) are given.

15915. Powell, D., Compaan, A., Macdonald, J. R., Forman, R. A., **Raman-scattering study of ion-implantation-produced damage in Cu_2O,** *Phys. Rev. B* **12,** No. 1, 20-25 (July 1, 1975).

Key words: cuprous oxide; implantation; ion; nondestructive testing; Raman scattering; sample characterization; semiconductor.

We present a Raman-scattering study of damage in Cu_2O which we have implanted with 90- and 180-keV Cd ions with doses ranging from 1.5×10^{11} to 1.5×10^{15} cm^{-2}. The Raman scattering was performed prior to annealing in order to study primarily the implantation-produced lattice damage. Using two argon-laser lines close to resonance with the 1*S* blue exciton, we observe changes from the pure-crystal Raman spectrum at all implantation doses. The unusual sensitivity of the technique can be interpreted in terms of damage-induced broadening of the intrinsic exciton states.

15916. Bennett, H. S., Forman, R. A., **Absorption coefficients in highly transparent solids: Barothermal theory for cylindrical configurations,** *Appl. Opt.* **14,** No. 12, 3031-3037 (Dec. 1975).

Key words: barothermal; gas pressure; heat diffusion; heat transfer; optical absorption coefficients; transparent materials.

The development of highly transparent solids requires improved methods to measure very low absorption coefficients at laser wavelengths. For the case in which a laser beam passes through a weakly absorbing solid that is surrounded by a confined, nonabsorbing gas, the temperature profiles in the solid and the temperature and pressure profiles in the gas have been calculated. Our calculations suggest that sufficient heat transfers from the solid into the gas to produce an easily detected pressure rise in the gas.

15917. Kahn, A. H., **Eddy currents and paramagnetic resonance in anisotropic conductors with application to TTF-TCNQ,** *J. Appl. Phys.* **46,** No. 11, 4965-4969 (Nov. 1975).

Key words: eddy currents; electron paramagnetic resonance; microwave conductivity; tetrathiofulvalinium-tetracyano-quinodimethane; TTF-TCNQ.

A theoretical analysis of the eddy currents in an anisotropically conducting solid is given. The geometry considered is that of a long rectangular prism with the applied rf field parallel to the length. The solution for the rf field in the solid has been found in terms of a Fourier series, and the dissipated power and average energy stored have been calculated. The changes in resonant frequency and quality factor of a microwave cavity into which a sample has been introduced are expressed in terms of the stored energy and dissipated power. Application is also made to the EPR absorption due to spins uniformly distributed throughout the sample, as outlined by Bloembergen. The asymmetric resonance line is similar to that of the infinite plate, but the peak line anisotropy is reduced as sample dimensions are decreased. The analysis is applied to samples of TTF-TCNQ and the results tabulated for varied sample sizes.

15918. Stillman, R. B., **FORTRAN analysis by simple transforms,** *Proc. Computer Science and Statistics East Annual Symposium on the Interface, Los Angeles, CA, Feb. 13-14, 1975,* 7 pages (1975).

Key words: execution; execution monitoring; FORTRAN analysis; source code instrumenting; static analysis; transforms.

Renewed interest in measuring program execution behavior has led to a number of distinct approaches. Arguments are given for a fairly simple method of modifying FORTRAN source code to collect frequency counts. No symbol table is necessary and only a single reserved name is introduced into the source.

15919. Unassigned.

15920. Kaufman, V., Sugar, J., **Resonance transition array of Yb IV,** *J. Opt. Soc. Am.* **66,** No. 5, 439 (May 1976).

Key words: energy levels; spectrum; wavelengths; ytterbium.

Nineteen pairs of lines in the wavelength range of 800-1300 Å were identified as transitions to the two levels of the ground term of Yb IV, $4f^{13}2F$. The $^2F_{5/2}-{}^2F_{7/2}$ interval is 10214.0 cm^{-1} with an rms deviation of 0.4 cm^{-1}.

15921. Joy, D. C., Leamy, H. J., Ferris, S. D., Yakowitz, H., Newbury, D. E., **Domain wall image contrast in the SEM,** *Appl. Phys. Lett.* **28,** No. 8, 466-467 (Apr. 15, 1976).

Key words: backscattered electrons; domain walls; magnetic domains; scanning electron microscope; silicon steel; transformer steel.

Contrast from domain walls in materials with cubic magnetic anisotropy has been observed in scanning electron microscope (SEM) images. This contrast, which is visible in both the backscattered and absorbed current images, with normal electron beam incidence arises from the interaction of the convergent incident electron beam with the domains on either side of the wall.

15922. Bower, V. E., Davis, R. S., **A new determination of the Faraday by means of the silver coulometer,** (Proc. 5th Int. Conf. on Atomic Masses and Fundamental Constants, Paris, France, June 1975), Paper in *Atomic Masses and Fundamental Constants* **5,** J. H. Sanders and A. H. Wapstra, Eds., Pt. 12, 578-583 (Plenum Press, New York, NY, 1976).

Key words: coulometry; electrochemical equivalent; electrochemical equivalent of silver; Faraday; silver.

A determination of the Faraday constant by means of the silver coulometer has been undertaken. The method consists of the direct anodic dissolution of a highly purified silver sample into a perchloric acid-silver perchlorate solution. The dissolution is carried out at constant current. The silver sample is weighed before and after the dissolution.

During the constant-current electrolysis, some solid silver inevitably falls from the electrode to the anode compartment floor. Still in the compartment, this residue is filtered, washed, converted to silver nitrate and reduced cathodically at constant potential. The sum of the current-time integrals for both electrolyses divided by the number of moles represented by the mass difference yields the Faraday constant.

The sources of systematic uncertainty affecting the measurement are the weighing (0.6 ppm), electrical measurements (0.3 ppm) and residue recovery (0.6 ppm), and the uncertainty (2 ppm) of the isotopic abundance ratio of the silver sample. The expected one-standard-deviation random uncertainty for a single measurement is 2.4 ppm and the standard deviation of the mean (8 degrees of freedom) is 0.85 ppm. A preliminary value of the Faraday with a combined uncertainty of 3.2 ppm is reported.

15923. Davis, R. M., **Managing computers for public service,** *Gov. Data Syst.*, pp. 17, 19 (July-Aug. 1973).

Key words: computers; data base management; governments; management information systems; public services; security; standards; user groups.

The size of our population, the variety of public services offered and public demands for accountability by government have increased 1) the recordkeeping functions of government, 2) the real-time control functions of government and 3) the amount of management and decision-making related to provision of public services.

Computers and computer technology are what make it possible for government to function effectively in these roles.

Federal, state and local governments must cooperate in a more formal way to properly utilize computers and to effectively resolve computer problems.

Problem areas include computer security, computer standards, management information system usage and performance measurements.

15924. Spector, N., Sugar, J., **Analysis of the fourth spectrum of terbium (Tb IV),** *J. Opt. Soc. Am.* **66,** No. 5, 436-438 (May 1976).

Key words: energy levels; ionization energy; spectrum; terbium.

The low-energy level structure of Tb^{3+} has been derived from spectra obtained with a sliding spark light source. The ^7F ground term of the $4f^8$ configuration was found as well as all levels of the configurations $4f^7 5d$, $6s$, and $6p$ built on the $^8S_{7/2}$ core state of $4f^7$. Of the possible 51 lines connecting these levels, 48 were observed. Optimized radial parameters are given for the observed configurations. A value for the ionization energy of 39.37(0.10) eV is derived for Tb^{3+}.

15925. Maki, A. G., Sams, R. L., **Infrared spectrum of $H^{12}C^{14}N$ and $H^{12}C^{15}N$,** *J. Mol. Spectrosc.* **60,** 57-62 (1976).

Key words: hydrogen cyanide; infrared; molecular spectroscopy; spectroscopy; vibrational fundamentals.

The high-resolution spectrum of $H^{12}C^{14}N$ has been measured near 4870 and 6060 cm^{-1}. The following bands have been identified and analyzed: $01^12\text{-}00^00$, $02^02\text{-}01^10$, $02^22\text{-}01^10$, $04^01\text{-}00^00$, $11^11\text{-}00^00$, $12^01\text{-}01^10$, and $12^21\text{-}01^10$. The C-N stretching fundamental (ν_3) of $H^{12}C^{15}N$ has also been measured near 2100 cm^{-1}. This fundamental is found to be 3 cm^{-1} higher than previously reported. Other bands that have been identified in the $H^{12}C^{15}N$ spectrum are $03^10\text{-}00^00$, $04^00\text{-}01^10$, $04^20\text{-}01^10$, and $01^11\text{-}01^10$.

15926. Juvet, R. S., Jr., Cram, S. P., **Gas chromatography,** *Anal. Chem.* **46,** No. 5, 101R-124R (Apr. 1974).

Key words: column materials; detectors; gas chromatography; theory of chromatography.

The literature in gas chromatography from January 1972 to 1974 is reviewed. Original contributions to the literature are discussed briefly and categorized in the areas of books and reviews, techniques, columns, detectors, identification and analysis, and miscellaneous topics. Special attention is given to those publications which represent fundamental contributions which are basic to the development of the technique.

15927. Julienne, P. S., Davis, J., **Cascade and radiation trapping effects on atmospheric atomic oxygen emission excited by electron impact,** *J. Geophys. Res.* **81,** No. 7, 1397-1403 (Mar. 1, 1976).

Key words: airglow; atomic oxygen; cascade radiation; emission cross section; radiation trapping.

The role of cascading in auroral or photoelectron excited atomic oxygen emission is investigated by calculating distorted wave electron impact cross sections for some 24 excited levels in O I. Cascading contributes ~75 percent of the effective emission cross section for 1304 Å and 1356 Å. About 98 percent of the cascade component to these ultraviolet lines is fed through the respective 8446-Å and 7774-Å transitions, with the consequence that the 4368-Å and 3947-Å emissions are very weak. The cascade component to 1304 Å is strongly enhanced in an optically thick medium due to radiation trapping of the lines from the $3s'\ ^3D$, nd^3D, and ns^3S ($n \geq 4$) levels to the ground state. The 1304-Å emission cross section appropriate in the optically thick atmosphere is predicted to be a factor of 2 larger than the emission cross section measured in an optically thin laboratory experiment. Consideration of this effect is necessary to understand the measured atmospheric 1304-Å/1356-Å ratio in terms of laboratory cross sections. Several recent atmospheric measurements on electron excited atomic oxygen 1304-Å, 1356-Å, 4368-Å, 7774-Å, and 1152-Å lines appear to be consistent with our calculated results, which imply that the Stone and Zipf (1974) 1304-Å and 1356-Å laboratory cross sections may be systematically too large by as much as a factor of 2.

15928. Feldman, A., McKean, W. J., **Improved stressing apparatus for photoelasticity measurements,** *Rev. Sci. Instrum.* **46,** No. 11, 1588-1589 (Nov. 1975).

Key words: photoelasticity; stressing apparatus.

An improved, direct reading stressing apparatus has been constructed for measuring photoelastic constants. Highly uniform stresses are obtained with minimal specimen tilt.

15929. Hubbard, C. R., Evans, E. H., Smith, D. K., **The reference intensity ratio, I/I_c, for computer simulated powder patterns,** *J. Appl. Crystallogr.* **9,** Part 2, 169-174 (Apr. 1976).

Key words: calculated powder patterns; I/I_c; microabsorption effects; quantitative phase analysis; quantitative powder diffraction; reference intensity ratios; systematic errors in powder diffraction.

A scale factor γ, to convert from the relative to the absolute/relative intensity scale, is readily calculated during computer simulation of powder patterns. Previously used scale factors are related to γ. The Reference Intensity Ratio, I/I_c (c=corundum), is obtained from μ, q, and γ for the sample and for corundum. Comparing calculated and experimental I/I_c values confirms that microabsorption and primary extinction can be serious experimental aberrations possibly limiting the accuracy to several wt.% in quantitative analysis by powder diffraction.

15930. Rosasco, G. J., Roedder, E., Simmons, J. H., **Laser-excited Raman spectroscopy for nondestructive partial analysis of individual phases in fluid inclusions in minerals,** *Science* **190,** 557-560 (Nov. 7, 1975).

Key words: chemical analysis; fluid interactions; geology; minerals; Raman spectroscopy.

Laser-excited Raman spectroscopy has been successfully applied to the identification and partial analysis of solid, liquid, and gaseous phases in fluid inclusions. The procedure is no panacea for problems of analysis of fluid inclusions, but some unique features make it very useful. In particular, the measurement is performed in situ, it is nondestructive, and it can produce qualitative and quantitative data, some of which cannot be obtained otherwise, for samples as small as 10^{-9} gram.

15931. Feldman, A., Waxler, R. M., Horowitz, D., **Measuring photoelastic and elastic constants of transparent materials by application of static stress,** (Proc. Int. Conf. on Optical Properties of Highly Transparent Solids, Waterville Valley, NH, Feb. 3-5, 1975), Paper in *Optical Properties of Highly Transparent Solids*, S. S. Mitra and B. Bendow, Eds., pp. 517-525 (Plenum Publishing Corp., New York, NY, 1975).

Key words: elastic constants; elasto-optic; photoelasticity; polycrystalline ZnSe; stress optical constants.

The shift of Twyman-Green and Fizeau fringes as a function of applied uniaxial and hydrostatic stress have been measured on transparent solids. These data permit us to calculate all the photoelastic and elastic constants of a material. At the wavelength 10.6 μm, where fringe shifts are small, we have measured photoelastic constants using a modified Twyman-Green interferometer, which is capable of detecting fringe shifts ~0.01 λ by electronic means. Data on polycrystalline ZnSe grown by chemical vapor deposition are presented.

15932. Dewey, H. J., **Second-harmonic generation in $KB_5O_8 \cdot 4H_2O$ from 217.1 to 315.0 nm,** *IEEE J. Quantum Electron.* **QE-12,** No. 5, 303-306 (May 1976).

Key words: doubling; laser; potassium pentaborate; u.v. generation.

Second-harmonic generation (SHG) has been observed in $KB_5O_8 \cdot 4H_2O$ (KB5) between 217.1 and 315.0 nm by angle tuning in a single crystal using a single cut. A conversion efficiency of 9.2 percent was observed for type I noncritical phase matching at 217.1 nm for a peak power of 15 kW at 434.2 nm. The nonlinear coefficients d_{31} and d_{32} are estimated to be approximately 1.1×10^{-10} ESU (4.0×10^{-25} m/V) and 0.08×10^{-10} ESU (0.29×10^{-25} m/V), respectively.

15933. Noyce, J. R., Hutchinson, J. M. R., Mann, W. B., Mullen, P. A., **Development of a National Bureau of Standards environmental radioactivity standard: River sediment,** (Proc. Int. Conf. on Environmental Sensing and Assessment, Las Vegas, NV, Sept. 14-19, 1975), Paper in *International Conference on Environmental Sensing and Assessment*, **1,** Session 19-5, 1-9 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: alpha particle; beta particle; gamma-ray; radioactivity; sediment; standard; x ray.

The National Bureau of Standards has developed and produced a radioactivity standard of a fresh-water sediment for use especially in environmental radioactivity measurements around nuclear and coal-burning electric power plants. The radioactivities of 28 nuclides in the sediment have been measured, of which 10 are certified. The development and production of this new Standard Reference Material (SRM 4350) are discussed.

15934. Olsen, P. T., Williams, E. R., **Determination of the gyromagnetic ratio of the proton γ_p',** (Proc. 5th Int. Conf. on Atomic Masses and Fundamental Constants, Paris, France, June 1975), Paper in *Atomic Masses and Fundamental Constants* **5,** J. H. Sanders and A. H. Wapstra, Eds., Part 11, 538-544 (Plenum Press, New York, NY, 1976).

Key words: fine structure constant; fundamental constants; gyromagnetic ratio of the proton.

The primary purpose of this paper is to present our latest value of γ_p' and the resultant value of the fine structure constant, α. The most accurate (2 ppm) and most recent value for γ_p' was reported at AMCO-4. That NBS value differs from other earlier values measured at several other national laboratories by about 8 ppm. To clarify this situation and to improve the earlier NBS value, we have spent the interim years developing an alternate, more accurate approach to the dimensional metrology problem. This approach now allows us to measure all critical dimensions by electromagnetic techniques and a simple one dimensional laser measurement. The only important dimensional measurement that has not been made by magnetic methods is the average diameter of the solenoid. We now envision a practical technique to realize this quantity by electromagnetic means. The diameter has, however, been measured by conventional methods and is of sufficient accuracy, when combined with all of the other uncertainties in the experiment, to provide a 0.42 ppm value for γ_p'. Since AMCO-4, the other experiments involved in the relationship $\alpha = C_0\ \gamma_p'^{1/2}$ have been improved so that C_0 is known to be better than 0.05 ppm. Therefore, our present results provide a 0.21 ppm value of α.

15935. Bennett, H. S., Forman, R. A., **An alternative way to determine absorption coefficients in highly transparent solids: Theory,** (Proc. Int. Conf. on Optical Properties of Highly Transparent Solids, Waterville Valley, NH, Feb. 3-5, 1975), Paper in *Optical Properties of Highly Transparent Solids*, S. S. Mitra and B. Bendow, Eds., pp. 451-459 (Plenum Publishing Corp., New York, NY, 1975).

Key words: calorimetry; laser; laser materials; optical absorption.

The development of highly transparent solids requires improved methods to measure very low absorption coefficients at laser wavelengths. We have calculated the temperature profiles in the solid and the temperature and pressure profiles in the gas when a laser beam passes through a weakly absorbing solid which is surrounded by a confined and nonabsorbing gas. Our calculations suggest that sufficient heat transfers from the solid to the gas to produce a detectable pressure rise in the gas.

15936. Bennett, H. S., Forman, R. A., **Measuring absorption coefficients of highly transparent solids by photoacoustic methods: Cylindrical configurations,** (Proc. 5th Conf. on Infrared Laser Window Materials, Las Vegas, NV, Dec. 1-4, 1975), Paper in *Proceedings of the 5th Conference on Infrared Laser Window Materials*, pp. 628-637 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, Feb. 1976).

Key words: absorption coefficients; cylindrical configurations; gas pressure; heat transfer; photoacoustic; transparent materials.

The development of highly transparent solids for fiber optics, integrated optics, and high-power lasers requires improved methods to measure very low absorption coefficients. A photoacoustic theory, which includes viscosity, has been developed for the case in which a laser beam, modulated at angular frequency ω passes through a weakly absorbing solid which is surrounded by a confined, nonabsorbing gas. The numerical predictions of this photoacoustic theory suggest that for sufficiently low frequencies and high ambient gas pressures, enough heat transfers from the solid to the gas to produce a detectable acoustic pressure signal at angular frequency ω in the gas. They also indicate that an absorbing layer at the solid-gas interface is not an essential mechanism for producing these detectable acoustic pressure signals. The model assumes that bulk absorption in the solid is the mechanism by which energy is transferred from the laser beam. Numerical examples for a typical laser glass are given.

15937. Feldman, A., Horowitz, D., Waxler, R. M., **Piezo-optical constants in the infrared,** (Proc. 5th Conf. on Infrared Laser

Window Materials, Las Vegas, NV, Dec. 1-4, 1975), Paper in *Proceedings of the 5th Conference on Infrared Laser Window Materials*, pp. 944-951 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, Feb. 1976).

Key words: elasto-optical constants; infrared materials; KCl; laser windows; photoelasticity; piezo-optical constants; refractive index.

The piezo-optical constants q_{11}, q_{12}, and q_{44}, and the elasto-optical constants p_{11}, p_{12}, and p_{44}, have been obtained at 10.6 μm for pure KCl grown by the reactive atmosphere process and for KCl nominally doped with 1 percent KI. Within experimental error, the coefficients of the two materials agree. Negligible dispersion is found for q_{11}, q_{12}, p_{11}, and p_{12} between the visible and 10.6 μm while a small dispersion is found for q_{44} and p_{44}.

15938. Feldman, A., Malitson, I. H., Horowitz, D., Waxler, R. M., Dodge, M. J., **Optical properties of polycrystalline zinc selenide,** (Proc. 4th Annual Conf. on Infrared Laser Window Materials, Tucson, AZ, Nov. 18-20, 1974), Paper in *Proceedings of the 4th Annual Conference on Infrared Laser Window Materials*, pp. 118-129 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, Jan. 1975).

Key words: chemical vapor deposited ZnSe; elastic compliance; elastic constants; polycrystalline ZnSe; refractive index; stress-optic constants; temperature coefficient of index; thermal expansion; ZnSe.

We have measured the following parameters of chemical vapor deposited polycrystalline ZnSe (CVD ZnSe): Refractive index and change of index of refraction with temperature (dn/dT) over the wavelength 0.5 μm to 18 μm using the method of minimum deviation; the coefficient of linear thermal expansion and dn/dT at 10.6 μm using Fizeau interferometry; and the elastic moduli and photoelastic moduli using Fizeau and Twyman-Green interferometry. A sensitive technique has been developed for measuring stress-optical constants of materials that exhibit a small stress-optical effect.

15939. Antonucci, J. M., Bowen, R. L., **Dimethacrylates derived from hydroxybenzoic acids,** *J. Dent. Res.* **55,** No. 1, 8-15 (1976).

Key words: acrylic resins; chemistry; composite resins; dental materials; hydroxybenzoic acids; pit and fissure sealants; preventive dental materials.

Aromatic ether-ester dimethacrylates were synthesized directly from the three isomeric hydroxybenzoic acids and 2-bromoethyl methacrylate by facile condensation reactions. The three crystalline monomers, on proper admixture, form a liquid ternary eutectic.

15940. Gilsinn, D. E., **The method of averaging and domains of stability for integral manifolds,** *SIAM J. Appl. Math.* **29,** No. 4, 628-660 (Dec. 1975).

Key words: averaging; differential equations; domains of stability; integral manifold; Liapunov functions; stability.

Liapunov's direct method is a standard and effective approach to computing the domain of stability (or region of attraction) of an autonomous ordinary differential equation. In this paper the author investigates domains of stability of integral manifolds of solutions generated by nonlinear mechanical and electrical oscillatory systems with many degrees of freedom. These manifolds are families of solutions that exhibit stronger stability properties than individual solutions. The problem of estimating the domain of stability of an asymptotically stable integral manifold is reduced to computing the domain of stability of an associated autonomous system of differential equations. This is done by applying the method of averaging to the system generating the integral manifold thus removing angular and time dependences. The stability region of this associated system is then computed and a result is established showing that this region is contained in the stability region of the original system. Several examples, including a coupled van der Pol system of oscillators, are considered.

15941. Johnson, P. M., **The multiphoton ionization spectrum of benzene,** *J. Chem. Phys.* **64,** No. 10, 4143-4148 (May 15, 1976).

Key words: benzene; electronic structure; multiphoton ionization.

A resonance seen in the multiphoton ionization spectrum of benzene at 391.4 nm is identified as a two-photon resonance with a bound state at 51 085 cm^{-1}. This state has probable symmetry $^1E_{1g}$ or $^1E_{2g}$ as indicated by an active e_{2g} vibration. No other allowed two-photon transitions are seen below this energy. Three-photon resonances with the Rydberg states of benzene are seen and compared to the one-photon absorption spectrum. The great similarity indicates a strong $^1A_{1g}$ component in the two-photon virtual state. Two-photon resonances with the $^1B_{2u}$ state agree with two-photon fluorescence excitation spectra but show no diminution above the energy where fluorescence is quenched.

15942. Dunn, G. H., **Electron impact ionization,** Proc. Int. Conf. on Heavy Ion Sources, Gatlinburg, TN, Oct. 27-30, 1975, *IEEE Trans. Nucl. Sci.* **NS-23,** No. 2, 929-933 (Apr. 1976).

Key words: electron-impact; ionization; ionization mechanisms; ions; review.

A brief review is given of electron impact ionization of atoms and atomic ions. As cross section measurements have been made for only about 1 percent of the atom and ion targets, comparisons are made between some of the recent measurements that have been made for ions and with calculations. Both semi-empirical and more "legitimate" calculations are compared. It is emphasized that mechanisms other than direct ionization can play an important role in ionization, so that predictions of cross sections should be considered cautiously.

15943. Frederikse, H. P. R., Hosler, W. R., Armstrong, A. J., Negas, T., **Spinels for MHD-electrodes,** (Proc. 15th Symp. on Engineering Aspects of Magnetohydrodynamics, The University of Pennsylvania, Philadelphia, PA, May 24-26, 1976), Paper in *Proceedings of the 15th Symposium on Engineering Aspects of Magnetohydrodynamics, Session II.2,* 1-4 (Dept. of Mechanical Engineering, University of Mississippi, University, MS, 1976).

Key words: durability; electrical conductivity; high temperature; MHD-power generation; spinel structure.

Solid solutions of Mg-chromite and Mg-aluminate spinels and magnetite appear to be promising materials for MHD electrodes. This paper presents high temperature electrical conductivity data and discusses some structural and chemical properties of these compounds. The Mg-Al-spinels show good resistance to seed corrosion, while the Mg-Cr-spinels appear to stand up well in a slagging environment. A third spinel, composed of Fe_3O_4 and Co_3O_4, is a very good electrical conductor and has potential as a lead-out material.

15944. Wasik, S. P., Brown, R. L., Minor, J. I., Jr., **Partition coefficients and solubility measurements of dimethylmercury in fresh and sea water over a temperature range 0-25 °C,** *J. Environ. Sci. Health—Environ. Sci. Eng.* **A11,** No. 1, 99-105 (1976).

Key words: dimethylmercury; partition coefficient; sea water; solubility.

The partition coefficients and solubilities of dimethylmercury in distilled and sea water over a temperature range 0-25 °C, have been measured using a head-space technique.

15945. Hubbard, C. R., Mauer, F. A., **Precision and accuracy of the Bond method as applied to small spherical crystals,** *J. Appl. Cryst.* **9,** Part 1, 1-8 (Feb. 1976).

Key words: Bond method; generalization of silicon; lattice, parameter of; lattice parameters; precision.

The Bond method for accurate lattice-parameter measurements has been applied to spheroidal crystals smaller in diameter than the incident beam. By measuring both $\bar{h}$ and $\bar{h}$ to reduce the effects of mis-centering and using a circle accurate to $\pm 0.001°$, a precision of a few parts per million can be attained. The accuracy of the method has been tested by measuring the lattice parameter of vacuum float-zone refined silicon by the conventional Bond method (using large, flat specimens) and by the modified method (using spheroidal specimens 0.25 mm in diameter). The results indicate that in addition to the usual corrections for refraction, emission-line asymmetry, and vertical divergence, a correction is required for changes in the asymmetric diffraction profile caused by the combined effects of horizontal divergence and absorption in the sphere. The correction is approximately 15 p.p.m. or 0.000079 Å in the case of the Si spheres and an instrument having a horizontal divergence of ± 0.0013 rad. The corrected lattice parameter agrees within 4 p.p.m. with results obtained by the conventional method. These results demonstrate the feasibility of making precise and accurate measurements on many materials that are not available in the form of large single crystals.

15946. Williams, J. G., Dicke, R. H., Bender, P. L., Alley, C. O., Carter, W. E., Currie, D. G., Eckhardt, D. H., Faller, J. E., Kaula, W. M., Mulholland, J. D., Plotkin, H. H., Poultney, S. K., Shelus, P. J., Silverberg, E. C., Sinclair, W. S., Slade, M. A., Wilkinson, D. T., **New test of the equivalence principle from lunar laser ranging,** *Phys. Rev. Lett.* **36,** No. 11, 551-554 (Mar. 15, 1976).

Key words: equivalence principle; general relativity; gravitation; lunar orbit; moon.

An analysis of six years of lunar-laser-ranging data gives a zero amplitude for the Nordtvedt term in the Earth-Moon distance yielding the Nordtvedt parameter $\eta = 0.00 \pm 0.03$. Thus, Earth's gravitational self-energy contributes equally, ±3 percent, to its inertial mass and passive gravitational mass. At the 70 percent confidence level this result is only consistent with the Brans-Dicke theory for $\omega > 29$. We obtain $|\beta - 1| \lesssim 0.02$ to 0.05 for five-parameter parametrized post-Newtonian theories of gravitation with energy-momentum conservation, or $|\beta - 1| \lesssim 0.01$ if only β and γ are considered.

15947. Taylor, B. N., Cohen, E. R., **Present status of the fundamental constants,** (Proc. 5th Int. Conf. on Atomic Masses and Fundamental Constants, Paris, France, June 1975), Paper in *Atomic Masses and Fundamental Constants* **5,** J. H. Sanders and A. H. Wapstra, Eds., Part 14, 663-673 (Plenum Press, New York, NY, 1976).

Key words: data analysis; fundamental constants; least-squares adjustments; quantum electrodynamics.

Since the completion of the authors' 1973 least-squares adjustment of the fundamental constants, and its subsequent official adoption for international use by the CODATA Task Group on Fundamental Constants and the 8th CODATA General Assembly, several relevant experiments and theoretical calculations have been completed. These include determinations of the Avogadro, Rydberg, Faraday and gas constants, the speed of light, a revised calculation of the sixth order contribution to the theoretical expression for the anomalous magnetic moment of the electron, and an improved calculation of the fine-structure in atomic helium. It is the purpose of this paper to examine the effect of these new results, and in as far as possible the effect of the most important relevant new experiments and calculations to be reported at this Conference, on the recommended output values of our 1973 least-squares adjustment.

15948. Mann, W. B., Schima, F. J., Unterweger, M. P., **Radioactivity standards of the Noble gases,** (Proc. Symp. on Noble Gases, Las Vegas, NV, Sept. 24-28, 1973), Chapter IV in *Noble Gases,* R. E. Stanley and A. A. Moghissi, Eds., ERDA TIC as Conf. 730915, pp. 144-153 (1975).

Key words: argon-37; direct standardization; environmental radioactivity; internal gas counters; isotope separator; krypton-85; proportional counters; radioactivity standardization; xenon-133, 131m.

The National Bureau of Standards gas-counting equipment is described. This consists of matched, length-compensated copper and stainless steel internal gas counters, which can be used in the proportional or Geiger-Mueller regions. The data acquisition and processing is by means of a computer-based multichannel analyzer. Methods for preparing relative standards based on measurements with ion chambers and fixed-geometry solid-state detectors are discussed. Noble-gas standards for argon-37, krypton-85, xenon-131m, and xenon-133 have so far been prepared, the last involving purification on the NBS isotope separator.

15949. Kurylo, M. J., Braun, W., **Flash photolysis resonance fluorescence study of the reaction $Cl+O_3 \rightarrow ClO+O_2$ over the temperature range 213-298 K,** *Chem. Phys. Lett.* **37,** No. 2, 232-235 (Jan. 15, 1976).

Key words: chlorine atoms; kinetics; ozone; resonance fluorescence; stratosphere.

Rate constants for the removal of Cl atoms in the reaction $Cl+O_3 \rightarrow ClO+O_2$ were measured by the flash photolysis resonance fluorescence technique over the temperature range 213-298 K. The rate constant is given by the Arrhenius expression $(2.94 \pm 0.49) \times 10^{-11} \exp[-(298 \pm 39)/T]$ in units of cm^3 $molecule^{-1}$ s^{-1}. Comparison with recent results from other laboratories are presented.

15950. Caswell, R. S., Coyne, J. J., **Microdosimetric spectra and parameters of fast neutrons,** *Proc. 5th Symp. on Microdosimetry, Verbania Pallanza, Italy, Sept. 22-26, 1975,* **EUR 5452** d-e-f, pp. 97-126 (1976).

Key words: energy deposition spectra; fast neutrons; initial spectra; microdosimetric parameters; nuclear data; slowing-down spectra.

Definitions and relationships of microdosimetric spectra and parameters for fast neutrons are discussed in the continuous slowing-down approximation (c.s.d.a.). Regions of validity of various calculational methods, including Monte-Carlo and c.s.d.a. are considered. Calculations and measurements of energy deposition spectra are compared. Calculations of microdosimetric parameters (from the energy deposition spectra) are compared with determinations of parameters from experimental spectra. Future needs for experimental energy deposition measurements, nuclear data, and charged particle stopping-power data are considered.

15951. Brandt, M. A., Truhlar, D. G., **Test of the infinite-order**

sudden approximation for electron scattering at intermediate energy, *Chem. Phys.* **13,** 461-467 (1976).

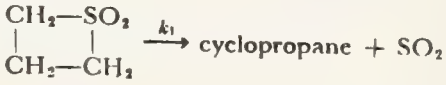
Key words: close coupling calculations; cross sections; differential cross sections; elastic scattering; electron scattering; momentum transfer; nitrogen molecules; rotational excitation; scattering theory; sudden approximation.

Converged infinite-order sudden (IOS) approximation calculations for electron scattering by N_2 at 30 eV are compared to converged close-coupling calculations. The IOS approximation is most accurate for the total scattering cross section.

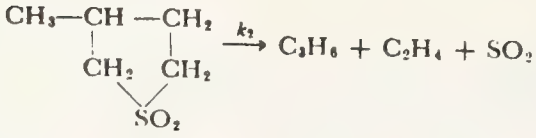
15952. Cornell, D., Tsang, W., **Thermal decomposition of trimethylene sulfone and 3-methyl sulfolane,** *Int. J. Chem. Kinet.* **VII,** 799-806 (1975).

Key words: pyrolysis; SO_2; trimethylene sulfone; 3-methyl sulfolane.

Trimethylene sulfone and 3-methyl sulfolane have been pyrolyzed using a modification of the toluene flow method and a comparative rate technique. The main decomposition reactions are



and



where $k_1=10^{16.1\pm0.3}$ exp $(-28{,}100\pm500/T)$ sec^{-1} and $k_2=10^{16.1\pm0.4}$ exp $(-33{,}200\pm750/T)$ sec^{-1}.

15953. Shih, A., Parsegian, V. A., **Van der Waals forces between heavy alkali atoms and gold surfaces: Comparison of measured and predicted values,** *Phys. Rev. A* **12,** No. 3, 835-841 (Sept. 1975).

Key words: alkali atoms; atomic beam deflection; atom surface potential; gold surfaces; Lifshitz theory; Van der Waals forces.

The Van der Waals potentials between heavy alkali-metal atoms (Cs, Rb, K) and gold surfaces have been investigated by the atomic-beam-deflection technique. The result is consistent with a potential of the form $V(R)=-k/R^3$. The observed interaction constant k is 7.0±0.29 D^2, 6.04±0.30 D^2, and 5.10±0.62 D^2 for Cs, Rb, and K, respectively. These values are smaller than the predictions based on all available theories. At best there is agreement within 60 percent for estimates based on the macroscopic continuum theory of Lifshitz. Other models disagree with measurements by factors of three (200% difference) or more.

15954. Epstein, M. S., Rains, T. C., O'Haver, T. C., **Wavelength modulation for background correction in graphite furnace atomic emission spectrometry,** *Appl. Spectrosc.* **30,** No. 3, 324-329 (May-June 1976).

Key words: graphite furnace atomic emission spectrometry; repetitive wavelength scanning; wavelength modulation.

The use of wavelength modulation for background correction in graphite furnace atomic emission spectrometry is shown to improve detection limits in some cases by several orders of magnitude and to increase its applicability to sample analysis. An HGA-2100 graphite furnace atomizer is used in conjunction with a 3/4-m monochromator equipped for wavelength modulation. A discussion of analytical growth curves, detection limits, scatter, and optimization of signal/noise ratio is presented. Copper is analyzed in botanical samples and the results are compared to analysis by atomic absorption and molecular absorption spectrophotometry.

15955. Newman, M., **On a theorem of Čebotarev,** *Linear and Multilinear Algebra* **3,** 259-262 (1976).

Key words: compounds; induced matrices; Kronecker powers; roots of unity; Schur matrix.

A new proof is given of the theorem that no submatrix of the $p\times p$ matrix $S=(\zeta^{(i-1)(j-1)})$ is singular, where ζ is a primitive pth root of unity and p is a prime. Some related results are also discussed.

15956. Berger, H., **Nondestructive evaluation: A review of nuclear methods,** (Proc. 22nd Int. Instrumentation Symp. on Aerospace Test Measurement, San Diego, CA, May 25-27, 1976), Paper in *22nd International Instrumentation Symposium,* B. Washburn, Ed., **13,** 427-437 (Instrument Society of America, Pittsburgh, PA, 1976).

Key words: neutron activation analysis; neutron gaging; neutron radiography; nondestructive evaluation; nuclear; radioactive tracers.

Nuclear methods for nondestructive evaluation (NDE) are reviewed. Gamma ray and neutron sources for NDE are tabulated and described. Nuclear NDE methods described include: (1) neutron and x-radiography and gaging, (2) scatter and secondary radiation techniques with emphasis on x-ray devices for analysis by characteristic x-ray emission and neutron moisture gages, (3) neutron activation analysis, and (4) radioactive tracer methods. Sensitivities and limits of detection are indicated and several examples are used to illustrate the methods. It is concluded that the nuclear method for NDE offers wide application potential and excellent sensitivity.

15957. Domalski, E. S., Tsang, W., **Assessing the hazard potential of chemical substances,** *Proc. 4th Int. Symp. on Transport of Hazardous Cargoes by Sea and Inland Waterways, Jacksonville, FL, Oct. 26-30, 1975,* pp. 259-274 (National Academy of Sciences, Washington, DC, 1975).

Key words: activation energy; bond dissociation energy; computer programs; explosive sensitivity tests; heat of decomposition; oxygen balance.

The ability to identify and specify the thermal instability of chemical substances has been appraised as a result of examining certain test methods used to measure explosive sensitivity, and certain computer programs designed to estimate reaction hazards from a thermochemical approach. The bond dissociation energy emerges as the parameter giving the best correlation with material sensitivity. The computer programs overemphasize explosive power as opposed to explosive sensitivity and label many compounds hazardous when they are not. At present, we recommend that regulations specifying the handling and transport of commodities should follow the concept of self-reactivity based upon functional groups (i.e., nitro, nitramine, peroxide, azide, etc.).

15958. Scheer, M. D., **The early afterglow in a pulsed helium discharge,** (Proc. XII Int. Conf. on Phenomena in Ionized Gases, Eindhoven, The Netherlands, Aug. 18-22, 1975), Paper in *Proceedings XII International Conference on Phenomena in Ionized Gases,* J. G. A. Holscher and D. C. Schram, Eds., p. 82 (North-Holland Publishing Co., The Netherlands, 1975).

Key words: collision model; early afterglow; electron temperature; helium metastables; helium plasma; pulse discharge.

Observations have been made of the concentrations of He(2^3S) metastables, ion-electron pairs, and electron temperatures during the first 500 μs of a decaying helium plasma after excitation by 1.5 kV, 50 μs pulse. It was found that during this early afterglow thermal and particle diffusion processes are negligible, the electron and gas temperatures are virtually constant, while the metastable and charged particle concentrations decay in accordance with a collision model using recently evaluated rate coefficients.

15959. Lamotte, M., Dewey, H. J., Ritter, J. J., Keller, R. A., **Laser induced photochemical enrichment of chlorine isotopes,** (Proc. 27th Int. Meeting of the Societe De Chimie Physique, on Lasers in Physical Chemistry and Biophysics, Thiais, France, June 17-20, 1975), Paper in *Lasers in Physical Chemistry and Biophysics,* J. Joussot-Dubien, Ed., pp. 153-164 (Elsevier Scientific Publishing Co., Amsterdam, The Netherlands, 1975).

Key words: chlorine isotope; isotope separation; laser-induced reaction; laser irradiation; photochemical reaction; thiophosgene.

There has been a lot of interest displayed in laser based isotope separation schemes. This interest lies in both uranium for defense and energy needs, and in the light isotopes for scientific, medical, and environmental studies. The principal advantage of a laser based process is that, in contrast to most enrichment schemes, energy is supplied only to the isotope of interest. An overview of the laser processes with emphasis on the use of visible lasers to enhance bimolecular, photochemical reactions is presented. Data on the successful enrichment of chlorine isotopes by the photochemical reaction between thiophosgene and diethoxyethylene is used to illustrate the major points.

15960. McLaughlin, W. L., **Radiation dosimeter colour,** Article in *Encyclopaedic Dictionary of Physics,* J. Thewlis, Ed., Suppl. 5, 248-251 (Pergamon Press Ltd., Oxford, England, 1975).

Key words: colour dosimeters; dosimetry; dyes; glass; plastics; radiation; radiochromic dyes; spectrophotometry.

Large doses (kilorads or greater) of ionizing radiation are known to change the hue, shade, or colour saturation of many substances. Just as extended exposure to sunlight causes some plastics to darken or turn slightly yellow or brown, and other materials to bleach or change colour ionizing radiations can cause even more radical changes in plastics, glasses, and certain dyed substances. As long as a critical portion of the resulting absorption spectrum or reflection spectrum is sufficiently stable and can be measured spectrophotometrically in a reproducible way, the material can be a useful dosimeter. The dosimetric response is given in terms of the change in optical transmission or reflection density, or change in percent transmittance or reflectance, at a given wavelength of light, as a function of the radiation absorbed dose in the material of interest. With this approach, any material susceptible to permanent radiation bleaching, colour change, or radiolytic darkening may serve as a colour radiation dosimeter.

15961. Bander, M., Shaw, G. L., Thomas, P., Meshkov, S., **Exotic mesons and e^+e^- annihilation,** *Phys. Rev. Lett.* **36,** No. 13, 695-697 (Mar. 29, 1976).

Key words: e^+e^- annihilation; exotic mesons; meson classification; ψ and χ particles; 1^{--} states.

Recent experiments at SPEAR indicate an unexpectedly large number of 1^{--} states in the energy range 3.9-4.4 GeV. We show how the existence of exotic $\bar{c}q\bar{c}q$ mesons can account for these states as well as the rise in R and the missing $\psi(3.7)$ decays. The width of these states does not require that they lie above the, as yet unobserved, $D\bar{D}$ threshold. Predictions of the model are readily testable.

15962. Karl, G., Meshkov, S., Rosner, J. L., **Symmetries, angular distributions in $\psi' \to \gamma\chi \to \gamma\gamma\psi$, and the interpretation of the $\chi(3400-3550)$ levels,** *Phys. Rev. D* **13,** No. 5, 1203-1215 (Mar. 1, 1976).

Key words: angular distributions; gamma-gamma correlations; quark models; symmetries; ψ particles; χ particles.

Recently a family of particles (to be denoted χ) has been discovered between 3400 and ~3550 MeV. A formalism is presented for analysis of the decays $\psi'(3684) \to \gamma\chi \to \gamma\gamma\psi$ or $\gamma 0^-0^-$ This formalism is sufficiently general to allow for transitions of several multipolarities. Previous treatments have been restricted to the assumption that the above transitions are purely $E1$ if $J^P(\chi) = 0^+$, 1^+, and 2^+. Here (with some model-dependent motivation) this restriction is removed. The predictions of specific heavy-quark models for the χ states are then discussed. On the basis of the single-quark-transition picture (the Melosh transformation), it is anticipated that the state $\chi(3410)$ will be identified as a $^3P_0$ $q\bar{q}$ level, and will be found to have $J^{PC} = 0^{++}$. It is also anticipated that the $^3P_2$ level should be fairly prominent.

15963. Keery, W. J., Leedy, K. O., Galloway, K. F., **Electron beam effects on microelectronic devices,** (Proc. 9th Annual Scanning Electron Microscope Symp., Toronto, Canada, Apr. 5-9, 1976), Paper in *Scanning Electron Microscopy,* O. Johari, Ed., **1,** Part IV, 507-514 (IIT Research Institute, Chicago, IL, 1976).

Key words: electron beam damage; electron beam energy deposition; ionizing radiation; microelectronic devices; scanning electron microscopy.

Scanning electron microscope (SEM) operators and the users of SEM information should be aware of the effects of the electron beam on microelectronic devices. An SEM examination is not necessarily a nondestructive test; device electrical parameters may be severely degraded. The effects of the SEM exposure are related to the energy deposited by the electron beam in the critical oxide layers of the device being examined. This deposited energy manifests itself electrically through the accumulation of trapped charge in the oxide and the generation of surface states at the oxide-silicon interface. These phenomena result in increased leakage currents and decreased gain for bipolar devices and altered threshold voltages and switching currents for metal-oxide-semiconductor (MOS) devices. By reviewing the physics and phenomenology of the effects of the electron beam on semiconductor device electrical parameters and relating these effects to the parameters of SEM exposure, it is shown that if a device is expected to function properly electrically after SEM examination, a careful analysis strategy should be developed before the device is placed in the SEM specimen chamber.

15964. Shoenfeld, P. S., DeVoe, J. R., **Statistical and mathematical methods in analytical chemistry,** *Anal. Chem.* **48,** No. 5, 403R-411R (Apr. 1976).

Key words: analytical chemistry; curve fitting; data reduction; feature selection; multivariate analysis; optimization techniques; pattern recognition; signal processing; spectral resolution; statistics.

A literature survey covering articles on mathematical and statistical methods in the analytical chemistry literature in the period October 1971 to January 1976. Areas discussed include spectral resolution, characterization and evaluation of the measurement process, optimization techniques, pattern recognition, and digital signal processing.

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15965. Newman, M., **Polynomials in a matrix,** *Linear and Multilinear Algebra* **3,** 263-266 (1976).

Key words: direct sums; formal power series; Jordan canonical form; permutation congruence; polynomials.

Let A be a matrix, $p(x)$ a polynomial. Put $B = p(A)$. It is shown that necessary and sufficient conditions for A to be a polynomial in B are (i) if λ is any eigenvalue of A, and if some elementary divisor of A corresponding to λ is nonlinear, then $p'(\lambda) \neq 0$; and (ii) if λ, μ are distinct eigenvalues of A, then $p(\lambda)$, $p(\mu)$ are also distinct. Here all computations are over some algebraically closed field.

15966. Kuehner, E. C., Cassatt, W. A., **A laser microphotometer for determining uniformity of particulate deposits on membrane filters,** *Appl. Spectrosc.* **30,** No. 3, 289-290 (May-June 1976).

Key words: laser; membrane filters; microphotometer; particulate deposits.

An apparatus for determining the uniformity of a layer of fine particles deposited on a membrane filter is described. A transmission scan of a laser beam across the filter deposit is a measure of the uniformity of the deposit layer. Quantitative estimates, with an accuracy of approximately 10 percent, of areal densities are inferred by calibration against reference deposits of ground orchard leaves on membrane filters.

15967. Yakowitz, H., Newbury, D. E., **A simple analytical method for thin film analysis with massive pure element standards,** (Proc. 9th Annual Scanning Electron Microscope Symp., Toronto, Canada, Apr. 5-9, 1976), Paper in *Scanning Electron Microscopy,* O. Johari, Ed., **1,** Part 1, 151-162 (IIT Research Institute, Chicago, IL, 1976).

Key words: distribution functions; electron probe microanalysis; semiconductor materials; thin films; x-ray fluorescence; x-ray microanalysis.

Conventional electron probe microanalysis quantitative techniques are not applicable to the case of thin film specimens. The situation is further complicated if the specimen lies upon a substrate. Typically, neither film thickness nor film composition is known. A number of investigators have devised schemes to deal with such specimens; these range from complex mathematical formulations to full scale Monte Carlo approximations. This paper offers a simple technique for determining composition and thickness which is based on empirical expressions for the distribution of x-ray generation in depth in the specimen; this distribution will be referred to as $\phi(z)$.

We have formulated an expression for $\phi(z)$ as a combination of a parabola and an exponential. The choice of parameters defining this expression is based on experimental $\phi(z)$ curves as well as Monte Carlo calculations. The required information for thin film analysis is the ratio of photons emitted from the film to photons emitted from the standard. (In our $\phi(z)$ model, mass fraction is the area under the $\phi(z)$ curve up to the film thickness divided by total area under the curve, where the shape of the entire curve has been corrected for absorption effects.) We have tested our model with a variety of data and have found, it produces results that are in good agreement with experimental findings.

15968. Dragoo, A. L., Paule, R. C., **Evaporation, diffusion and convection in containerless melts at low gravity,** *AIAA J.* **14,** No. 2, 135-136 (Feb. 1976).

Key words: Al_2O_3; complex equilibria; convective diffusion; evaporative rate; purification (evaporative); solutal-capillary; thermal capillary convection; vacuum vaporization.

In the preparation of ultrapure refractory materials, contamination from containers is a major problem. Space with its zero gravity, high vacuum conditions offers an opportunity for containerless purification of materials. Processes which often involve complex chemical equilibria can be used to convert impurities to forms that can be distilled off. Thermodynamic calculations have been modified to describe evaporative purification into vacuum. The contributions of diffusion and of Marangoni convection to mass transfer rates in the bulk liquid have been estimated. Examples of evaporative purification will be given.

15969. Feldman, A., Horowitz, D., Waxler, R. M., **Stress-optic measurements in the infrared,** (Proc. Third Conf. on High Power Infrared Laser Window Materials, Hyannis, MA, Nov. 12-14, 1973), Paper in *Third Conference on High Power Infrared Laser Window Materials. II. Materials,* C. A. Pitha, A. Armington, and H. Posen, Eds., AFCRL-TR-74-0085(II), Special Reports, No. 174, pp. 403-409 (Air Force Cambridge Research Laboratories, Bedford, MA, Feb. 14, 1974).

Key words: crystals; damage; glass; infrared; interferometry; lasers; photoelasticity; polarimetry.

Twyman-Green and Fizeau interferometers have been constructed for measuring absolute stress-optic coefficients in infrared materials at 1.15 μm and 10.6 μm. The specimen, in the form of a rectangular parallelepiped, is compressed uniaxially in a rectangular frame screw clamp. The stress-optic coefficients are calculated from the measurement of fringe shifts as a function of stress. Preliminary measurements are presented for a chalcogenide glass.

15970. Parks, S. I., Johannesen, R. B., **An algorithm for automatic correction of quadrature phase detector outputs,** *J. Magn. Reson.* **22,** 265-267 (1976).

Key words: computer program; Fourier transform NMR; homonuclear lock; phase adjustment; phase correction algorithm; quadrature.

A computer algorithm is described which automatically corrects phase and amplitude errors when quadrature phase detectors are used in Fourier transform NMR. A procedure for averaging unlocked scans in the time domain is discussed.

15971. Bennett, H. S., Forman, R. A., **Absorption coefficients of highly transparent solids: Photoacoustic theory for cylindrical configurations,** *Appl. Opt.* **15,** No. 5, 1313-1321 (May 1976).

Key words: absorption coefficients; heat diffusion equations; highly transparent solids; hydrodynamic equations; optical materials; photoacoustic method.

The development of highly transparent solids for fiber optics, integrated optics, and high power lasers requires improved methods to measure very low absorption coefficients. For the case in which a laser beam, modulated at angular frequency ω, passes through a weakly absorbing solid which is surrounded by a confined, nonabsorbing gas, the temperature profiles in the solid and the temperature and pressure profiles in the gas have been calculated. The calculations suggest that for sufficiently low frequencies and high ambient gas pressures, enough heat transfers from the solid to the gas to produce a detectable acoustic-pressure signal at angular frequency ω in the gas. They also indicate that an absorbing layer at the solid-gas interface is not an essential mechanism for producing these detectable acoustic pressure signals. The model assumes that bulk absorption in the solid is the mechanism by which energy is transferred from the laser beam. Numerical examples for a typical laser glass are given.

15972. Hughes, E. E., **Development of standard reference materials for air quality measurement,** *ISA Trans.* **14,** No. 4, 281-291 (1975).

Key words: air pollution; carbon monoxide; gas analysis; gas standards; nitric oxide; nitrogen dioxide; sulfur dioxide.

The National Bureau of Standards is engaged in a continuing program involving gaseous Standard Reference Materials for air pollution measurements. Preparation of such materials requires definition of the stability, homogeneity, and accuracy of the samples. This information is obtained by long term studies of the gas systems, by development of absolute methods of analysis, and by analysis of large numbers of samples prepared in bulk. The results of studies, extending over several years, of low concentration of carbon monoxide in nitrogen and nitric oxide in nitrogen are reported. Over one thousand samples of these materials have been analyzed and the stability with time and the within-batch homogeneity have been characterized. Accuracy is achieved by use of gravimetric standards and with dynamic dilution systems. Accuracy attainable by either method is described.

The use of permeation tubes of sulfur dioxide and nitrogen dioxide is necessary in some situations because of the reactivity of the gases. Data covering the stability and accuracy of these devices has been collected over a period of several years.

15973. Choi, C. S., Prince, E., **A neutron diffraction study of structure and thermal motion in several monovalent metal azides,** *J. Chem. Phys.* **64,** No. 11, 4510-4516 (June 1, 1976).

Key words: ionic crystal; KN_3 structure; low temperature study; monovalent metal azides; NaN_3 structure; neutron diffraction; RbN_3 structure; thermal motion; TlN_3 structure.

The crystal structures of the monovalent metal azides β-NaN_3, KN_3, TlN_3, and RbN_3 were reinvestigated by means of neutron diffraction. All except β-NaN_3 were studied at low temperature as well as at room temperature. These compounds form ionic crystals with spherical metal cations and linear azide anions. Because the azide ions in each case occupy centrosymmetric sites, their thermal motions can be treated, except for the small amplitude N-N stretching and the internal bending motions, as the motions of rigid bodies without screw correlations. All structures were, therefore, refined using rigid-body constraints, leading to final R values, both weighted and unweighted, ranging from 0.020 to 0.045. KN_3, TlN_3, and RbN_3 all crystallize in the tetragonal space group $I4/mcm$, while β-NaN_3 crystallizes in the space group $R\bar{3}\ m$. The uncorrected N-N distances range from 1.159 to 1.183 Å, but when corrections for thermal motions are applied all distances except for β-NaN_3 lie in the range 1.181-1.187 Å, with a weighted mean of 1.186 Å. In the β-NaN_3 the corrected N-N distance is 1.180(1) Å. This apparently unusually short distance may be attributable to disorder, with the axis of the N_3 group making a small angle with the c axis. In the tetragonal crystals, where the azide ions occupy sites with mmm symmetry, the anisotropy of libration is consistent with the steric hindrance in the structure. The librational amplitudes determined from the diffraction studies were compared with those determined by Raman scattering, and the agreement is satisfactory.

15974. Gatehouse, B. M., Negas, T., Roth, R. S., **The crystal structure of M-$LiTa_3O_8$ and its relationship to the mineral wodginite,** *J. Solid State Chem.* **18,** 1-7 (1976).

Key words: crystal structure; lithium tantalate; M-$LiTa_3O_8$; wodginite.

M-$LiTa_3O_8$ crystallizes in the monoclinic system with unit-cell dimensions (from single crystal data) a=9.413, b=11.522, c=5.050 Å, β=91.05°, and space group $C2/c$, Z=4. The structure was solved using three-dimensional Patterson and Fourier techniques. Of the 754 reflections measured by counter techniques, 714 with $I \geq 3\sigma\ (I)$ were used in the least-squares refinement of the model to a convention R of 0.043 (wR=0.055). M-$LiTa_3O_8$ has the α-PbO_2 type of structure with hexagonally close-packed oxygen ions with lithium and tantalum occupying octahedral sites in an ordered way. This structure can be regarded as a simple analogue of the complex mineral wodginite.

15975. Cameron, J. M., **Traceability?,** *J. Qual. Technol.* **7,** No. 4, 193-195 (Oct. 1975).

Key words: measurement; traceability; uncertainty.

The requirement of traceability of instruments to nationally accepted standards or measurement systems has as its goal the adequate accuracy of measurement, the compatibility of different measurement systems, the interchangeability of parts, etc. This note discusses a perspective in which these goals are approached directly by performance requirements on the quality of measurement rather than a property of an instrument, namely traceability.

15976. Cameron, J. M., **Measurement assurance,** *J. Qual. Technol.* **8,** No. 1, 53-55 (Jan. 1976).

Key words: measurement; measurement assurance; uncertainty.

There is an obvious need that measurements in the fields of health, safety, environmental control and nuclear safeguards be adequate for their intended purpose—that their uncertainty be small enough to only negligibly affect the decisions and performance of the processes of which they are a part, but it is no less true for all other measurements in science and industry. This note discusses the procedures by which one obtains measurement assurance, the analog for measurement processes of industrial quality assurance.

15977. Loevinger, R., Berman, M., **A revised schema for calculating the absorbed dose from biologically distributed radionuclides,** *J. Nucl. Med. MIRD Pamphlet No. 1,* Revised, 3-10 (Mar. 1976).

Key words: absorbed dose; calculation; dosimetry; nuclear medicine; radionuclide; radiopharmaceutical.

This paper is a revision of the first pamphlet in the series of publications by the Medical Internal Radiation Dose Committee (MIRD) of the Society of Nuclear Medicine. That pamphlet presented a new formalism for dosimetry calculation in nuclear medicine, and has served as the basis for a series of MIRD publications. This revised schema is intended to be a clearer and more direct presentation of the same formalism, the purpose of which is to produce a convenient uniformity and simplicity in the calculation of absorbed dose from radiopharmaceuticals.

15978. Taylor, J. K., **Evaluation of data obtained by reference methods,** (Proc. American Society for Testing and Materials Symp. on Calibration in Air Monitoring, Boulder, CO, Aug. 4-8, 1975), *Am. Soc. Test. Mater. Spec. Tech. Publ. 598,* pp. 156-163 (1976).

Key words: air pollution; calibration; evaluation; intercalibration; quality control; standards.

The key role of reference methods for measurement of air pollutants in regulatory matters demands that the data obtained in their use be precise and accurate, but no procedures have been established for evaluating its reliability and validity for the intended use. This paper discusses the general principles of reliable analytical measurements and presents guidelines by which

the quality of data obtained by reference methods or other procedures may be evaluated.

15979. Taylor, B. N., **Is the present realization of the absolute ampere in error?,** *Metrologia* **12,** No. 2, 81-83 (1976).

Key words: absolute ampere; fundamental constants; Josephson effect.

Using the results of recent experimental determinations of several different fundamental physical constants, highly accurate, indirect values for the ratio of the as-maintained ampere to absolute ampere may be obtained. A comparison of these indirect values with the results of direct determinations based on force balances and with the presently accepted best value indicates that both of the latter may be in error.

15980. Hall, J. L., **Stabilized lasers and the speed of light,** (Proc. 5th Int. Conf. on Atomic Masses and Fundamental Constants, Paris, France, June 1975), Paper in *Atomic Masses and Fundamental Constants* **5,** J. H. Sanders and A. H. Wapstra, Eds., Part 8, 322-329 (Plenum Press, New York, NY, 1976).

Key words: frequency multiplication; fundamental constants; laser stability; metrology; second-order Doppler shift; speed of light.

This paper recalls the developments in laser frequency stabilization and in accurate measurement of laser wavelengths and frequencies. The CCDM(73) found good agreement among the reporting laboratories for the wavelength of the CH_4-stabilized laser and so recommended a value in meters. A recent NPL measurement of the CH_4 frequency confirmed the NBS value and so substantiates the CCDM-recommended value of the speed of light, c. NPL also reported independent λ and f measurements on a stabilized CO_2 laser, yielding the same value for $c-$to within the uncertainty of the Meter. The present status of the krypton-based International Meter is reviewed and a number of new laser systems of potential metrological interest are noted. Finally, we focus on the future possibilities for optical frequency standards. We report preliminary measurements of the pressure effect on the height ratio of the now-resolved recoil doublet in CH_4. This resolution, approaching 1 kHz at $\sim 10^{14}$ Hz, is the highest ever employed in spectroscopy with coherent fields. Limiting factors of an optical frequency standard are recalled and an accuracy capability of 2×10^{-13} is estimated for the present apparatus.

15981. Johnson, P. M., **The multiphoton ionization spectrum of trans-1,3-butadiene,** *J. Chem. Phys.* **64,** No. 11, 4638-4644 (June 1, 1976).

Key words: electronic structure; multiphoton ionization; trans-1,3-butadiene.

The multiphoton ionization spectrum of *trans*-1,3-butadiene has been measured from dye laser wavelengths of 365 to 468 nm using an intensity-corrected system. In the four-photon ionization region to lower energy than 405 nm, many three-photon resonances with Rydberg states are seen and a new series with a quantum defect of 0.04 is identified. The symmetries of the observed Rydberg series are discussed. Above 405 nm in energy, a resonance occurs with the $\tilde{B}$ state seen in one-photon absorption spectra, only the structure in the multiphoton ionization spectrum is characteristic of an allowed two-photon resonance. From the vibronic structure of this state, it is argued that it has symmetry ^1B_u. In the region covered by this study (42 700 to 54 800 cm^{-1} in two-photon energy) no state was found to which a ^1A_g symmetry designation could be applied.

15982. Hughes, E. E., **Role of the National Bureau of Standards in calibration problems associated with air pollution measurements,** (Proc. American Society for Testing and Materials Symp. on Calibration in Air Monitoring, Boulder, CO, Aug. 4-8, 1975), *Am. Soc. Test. Mater. Spec. Tech. Publ. 598,* pp. 223-231 (1976).

Key words: air pollution; analyzing; gas analysis; gases; emission; monitors; standards.

The National Bureau of Standards (NBS) produces a limited number of Standard Reference Materials (SRM's) for air pollution and related analyses. The effort involved in the preparation and certification of these standards precludes production in large quantities or of great variety. The requirements for accuracy and stability of samples necessitate a considerable research effort prior to production of the actual SRM's. The decision as to what gas mixtures will be prepared as SRM's is based primarily on a demonstrated need modified by anticipated demand and by other obligations of the SRM program. The demand for these SRM's is increasing, and maintaining stocks of current SRM's must compete with the necessary research prior to issuance of new SRM's.

Comparisons are presented of independent analyses of a number of SRM's currently in use for measurement of automotive emissions.

15983. Heinrich, K. F. J., **Empirical approaches for the treatment of interelement effects,** (Proc. 24th Annual Conf. on Applications of X-Ray Analysis, Denver, CO, Aug. 6-8, 1975), Chapter in *Advances in X-Ray Analysis,* R. W. Gould, C. S. Barrett, J. B. Newkirk, and C. O. Ruud, Eds., **19,** 75-84 (Kendall/Hunt Publ. Co., Dubuque, IA, 1976).

Key words: corrections; matrix effects; standard reference materials; x-ray fluorescence.

Empirical algorithms for the treatment of interelement effects in x-ray fluorescence spectrometry are reviewed. It is recommended that the effects of tertiary x-ray emission be treated separately from those of x-ray absorption, and that standard reference materials of composition close to that of the specimen be used.

15984. Pella, P. A., Kuehner, E. C., Cassatt, W. A., **Development of a particulate reference sample on membrane filters for the standardization of x-ray fluorescence spectrometers,** (Proc. 24th Annual Conf. on Applications of X-Ray Analysis, Denver, CO, Aug. 6-8, 1975), Chapter in *Advances in X-Ray Analysis,* R. W. Gould, C. S. Barrett, J. B. Newkirk, and C. O. Ruud, Eds., **19,** 463-472 (Kendall/Hunt Publ. Co., Dubuque, IA, 1976).

Key words: calibration; filters; orchard leaves; reference sample; x-ray analysis.

Particulate reference samples have been prepared for the standardization of x-ray fluorescence spectrometers used in the analysis of air particulate matter. Uniform layers of reground orchard leaves of known composition, i.e., National Bureau of Standards Standard Reference Material SRM 1571, were deposited on membrane filters and coated with a thin polymer film for protection against abrasion and moisture. These samples have been prepared with areal densities of 0.1 to 5.0 mg/cm^2.

15985. Siedle, A. R., **Group VIb metal carbonyl complexes of 1,3-dithiolene-2-thione,** *Inorg. Nucl. Chem. Lett.* **11,** No. 5, 345-347 (1975).

Key words: chromium carbonyl; infrared spectroscopy; metal carbonyl; molybdenum carbonyl; NMR spectroscopy; 1,3-dithiolene-2-thione.

Reaction of 1,3-dithiolene-2-thione with bicyclo{2,2,1}heptadiene $M(CO)_4$ (M=Cr, Mo) produces (1,3-dithiolene-2-thione)$M(CO)_5$.

15986. Flynn, D. R., **Measurement of thermal conductivity by steady-state methods in which the sample is heated directly by passage of an electric current,** Chapter 5 in *Thermal Conductivity*, R. P. Tye, Ed., **1,** 242-300 (Academic Press, London and NY, 1969).

Key words: conductivity; electrical; heat conductivity; heat transfer; Lorenz function; thermal conductivity.

A survey is made of the field of thermal conductivity measurement by the category of methods in which the sample is heated directly by passage of an electric current. A mathematical analysis of simultaneous steady-state heat and electric current in a conductor is given. This analysis is then applied to several methods which have been used for determination of thermal conductivity. A critical description is given of the experimental procedures followed by numerous investigators who have made thermal conductivity measurements by electrical heating methods. Finally, some problem areas are discussed and recommendations are given for further work in this area.

15987. Linsky, J. L., Glackin, D. L., Chapman, R. D., Neupert, W. M., Thomas, R. J., **The solar XUV spectrum of He II,** *Astrophys. J.* **203,** No. 2, 509-520 (Jan. 15, 1976).

Key words: atomic processes; sun, corona; sun, flares; sun, prominences; sun, spectra; ultraviolet, spectra.

OSO-7 observations of the first five Lyman lines and the Lyman continuum of He II are given for the quiet Sun, a coronal hole, prominences, filaments, and the 1972 August 7 flare. These data are calibrated and given in specific intensity units together with color and brightness temperatures for the He II continuum. We find that He II is overionized in all features except the flare, and that the continuum is formed at temperatures near 14,000 K. The He II–He III ionization equilibrium appears to be dominated by photoionizations and radiative recombinations. Schematic calculations for realistic chromosphere and transition-region models can account for the observed intensities of $L\beta - L\epsilon$, the Lyman continuum, and its color temperature. To account for the intensity of $L\alpha$, either an implausible 100 km plateau at temperatures near 80,000 K is needed or, more likely, the incorporation of diffusion-enhanced collisional excitation into the models.

15988. Cook, J. M., Evenson, K. M., Howard, C. J., Curl, R. F., Jr., **Laser magnetic resonance spectrum of HCO on the D_2O 108 μ laser line,** *J. Chem. Phys.* **64,** No. 4, 1381-1388 (Feb. 15, 1976).

Key words: laser line; laser magnetic resonance spectrum; magnetic resonance spectrum; resonance spectrum; rotational frequency.

An LMR spectrum on the 108 μ D_2O laser line has been observed and assigned to the $8_{2,6} \leftarrow 7_{1,7}$ rotational transition of HCO. The spectra of both π (parallel) and σ (perpendicular) polarizations have been fitted by the least squares method, giving excellent agreement between the calculated and observed magnetic fields. The rotational frequency obtained from the fittings has been used to determine the A rotational constant. In addition, the electron spin-rotational splitting of each rotational level and the Fermi constant have been determined.

15989. Sanders, D. M., Schaefer, H. A., **Reactive vaporization of soda-lime-silica glass melts,** *J. Am. Ceram. Soc.* **59,** No. 3-4, 96-101 (Mar.-Apr. 1976).

Key words: diffusion; glass; homogeneity; melting; vaporization.

Water-vapor-assisted transport of glass constituents from a soda-lime-silica melt was studied, using atomic spectroscopy for analysis of vapor condensates and microprobe analysis to determine diffusion profiles. The data presented indicate that the vaporization process is controlled by a surface membrane which has a composition different from the bulk composition. The influence of this effect on glass homogeneity is discussed.

15990. Kaufman, V., Radziemski, L. J., Jr., **The sixth spectrum of uranium (U VI),** *J. Opt. Soc. Am.* **66,** No. 6, 599-600 (June 1976).

Key words: actinide; atomic energy levels; isoelectronic sequence; protactinium; rare earth; sliding spark discharge lamp; spectrum; uranium.

Eight spectral lines of five-times ionized uranium between 800 and 1930 Å are reported. Four terms ($5f^2F$, $6d^2D$, $7s^2S$, and $7p^2P$) are given. Isoelectronic comparisons are made and the effect of crystal fields on the $5f$ electron is discussed.

15991. Miles, M. G., Wager, J. S., Wilson, J. D., Siedle, A. R., **Reactions of 4,5-dicyano-1,3-dithiole-2-thione and -1,3-dithiol-2-one with tervalent phosphorus compounds,** *J. Organ. Chem.* **40,** No. 18, 2577-2582 (1975).

Key words: aryl phosphines; cyclic voltammetry; desulfurization; phosphines; tetracyanotetrathiafulvalene; tetracyanotetrathiafulvalene·triphenylphosphine; $\Delta^{2,2'}$-bis-14.5-dicyano-1,3-dithiodene; 1,3-dithiolenes; ^{31}P NMR; 4,5-dicyano-1,3-dithiolene-2-thione.

In contrast to other reported reactions of 1,3-dithiol-2-ones and 1,3-dithiole-2-thiones with tervalent phosphorus compounds, which yield only tetrathiafulvalenes, the reaction of 4,5-dicyano-1,3-dithiole-2-thione (1) and -1,3-dithiol-2-one (2) with phosphines and phosphites is complex. Either tetracyanotetrathiafulvalene [$\Delta^{2,2'}$-bi(4,5-dicyano-1,3-dithiolidene)] (3), a betaine {(4,5-dicyano-1,3-dithiol-2-ylidene)methylene [tri-(substituents)phosphonio](- 2 - thio - 1 - mercaptomaleonitrilate)} (4), or a dialkyl (4,5-dicyano-1,3-dithiol-2-yl)phosphonate may be formed, depending on the choice of reactant and conditions. In addition, Wittig-type products are formed on addition of aryl aldehydes to the reaction mixture. All of these products can be rationalized by means of a reaction scheme which assumes the ylide 4,5-dicyano-1,3-dithiolidenetri(substituent)phosphorane to be the key intermediate. Only tetracyanotetrathiafulvalene was isolated from the reaction of trimethyl phosphite with either 1 or 2 and tris(*p*-chlorophenyl)phosphine with 1, but reactions of other triarylphosphines and methyl diphenylphosphinite with 1 yielded varying amounts of fulvalene and betaine. Phosphorus trichloride, triphenyl phosphite, and triphenylarsine did not react with 1. The stoichiometric reaction of triphenylphosphine, 1, and terephthalaldehyde gave a near-quantitative yield of 2,2′-*p*-xylylidenebis(4,5-dicyano-1,3-dithiole) (8), which undergoes a reversible, electrochemical oxidation at E_p=1.07 V (vs. SCE) and an irreversible oxidation at E_p=1.39 V. With benzaldehyde under these conditions, however, both 4 and 2-benzylidene-4,5-dicyano-1,3-dithiole were isolated. The novel ester dimethyl (4,5-dicyano-1,3-dithiol-2-yl)phosphonate was isolated from a reaction of trimethyl phosphite plus 2 in the presence of benzoic acid.

15992. Gutschick, K. A., Clifton, J. R., **Durability study of 14-year old masonry wallettes,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 589, Masonry: Past and Present*, 76-95 (Aug. 1975).

Key words: lime (dolomitic); masonry; mortars (materials); portland cement; testing; walls.

A series of brick wallettes originally built to study the effect of five variables, particularly dolomitic lime, on dimensional stability were analyzed as to their durability performance after 14 years of outdoor exposure. Durability performance was assessed

in terms of cracking (bond separation), mortar erosion, and efflorescence, with the influencing factors including type of lime, mortar, and brick, loading, climate, and exposure.

Generally, most walls performed well, considering that they in essence were "parapet" walls, unprotected from the elements on all sides. The greatest incidence of cracking occurred in walls built with the dense, low absorptive white brick and mortar made with high expansive lime; frost action was undoubtedly a contributing factor. Mortar erosion was most prevalent on the south faces of walls, particularly in walls built with the high absorptive red brick and mortar made with high expansive lime; thermal expansion was undoubtedly a contributing factor. Efflorescence was only slight. The study points to the importance of using compatible mortar-brick combinations to get the best performance.

15993. Halsey, N., **GFRP rod and rope for structural guy applications,** *ASCE J. Engr. Mech. Div.* **100,** No. EM4, 673-685 (Aug. 1974).

Key words: end fittings; GFRP rod and rope; structural guys.

Tensile tests were conducted on GFRP rod and rope using five commercial structural guy termination grips and the relative performances of the grips with these materials were evaluated. Stress-rupture tests at moderately elevated temperatures under low and saturated humidity conditions were carried out on two GFRP rod and rope materials and the stress-rupture characteristics of the materials were examined. Flexural tests were performed on three GFRP rod and rope materials from +77 to −80 °F and the flexural moduli of the materials were evaluated. Simulated aeolian vibration tests were carried out on two GFRP rod and rope materials held under constant tensile loads using four types of commercial guy-termination grips and an NBS shear-type grip. The resistance to damage of these materials from aeolian vibration was observed up to 10^8 cycles. A series of 30-day storage tests were conducted on four GFRP rod and rope materials at temperatures ranging from 125 to 200 °F. Several guidelines regarding minimum coil diameters and maximum exposure temperatures for long-term storage were established. Some residual strength tests were performed on the materials which had been exposed to long-term storage.

15994. Zuckerman, B., Turner, B. E., Johnson, D. R., Palmer, P., Morris, M., **A new interstellar line: The 5_1-4_0 (E_2) transition in methyl alcohol,** *Astrophys. J.* **177,** No. 3, 601-607 (Nov. 1, 1972).

Key words: emission line; interstellar medium; laboratory measurement; methyl alcohol; population inversion; radio astronomy.

An emission line has been detected at 84.5 GHz in the direction of the radio continuum source Sgr B2. The new line frequency has been found to coincide with a laboratory measurement of the $5_1 \rightarrow 4_0$ (E_2) transition of methyl alcohol (CH_3OH). Calculations of the spontaneous emission rates from all energy levels of astrophysical interest have been performed; these indicate that not only the 5_1-4_0 (E_2) transition in Sgr B2 but also the $\Delta J=0$, $\Delta K=1$(E_1) transitions discovered in Orion A by Barrett *et al.* are likely to have population inversions.

Additional searches for NH_2CN, HCP, CH_3Cl ClCN, FeO, HC_3HO, and NH_2HCO were carried out in the 80-92-GHz region without success.

15995. Bushnell, D. L., Jr., Huebner, R. H., Celotta, R. J., Mielczarek, S. R., **Preliminary report on electron energy-loss measurements for $CClF_3$, CCl_2F_2, and CCl_3F,** *Argonne Natl. Lab. Report No. ANL-75-60,* Part I. Radiological and Environmental Research Annual Report on Fundamental Molecular Physics and Chemistry, pp. 7-17 (Argonne National Laboratory, Argonne, IL, July 1974-June 1975).

Key words: $CClF_3$; CCl_2F_2; electron energy-loss; freons; uv photoabsorption.

Currently, nationwide research efforts are devoted to studying the possible ozone (O_3) depletion in the stratosphere by the chemical action of chlorine atoms released from CCl_2F_2 or CCl_3F upon absorption of ultraviolet radiation. Since electron-impact data taken in the forward scattering direction can be used to derive oscillator strengths and thus to yield apparent photoabsorption cross sections, we have carried out such an analysis for CCl_2F_2, CCl_3F, and $CClF_3$. We obtain oscillator-strength distributions between 5 and 20 eV and compare these to available photoabsorption data. Certain photoabsorption values agree very well with this electron-impact data, but other optical studies deviate in some spectral regions by as much as a factor of 5. Also, the electron energy-loss spectrum reveals electronic transitions previously undetected by photoabsorption.

15996. Wallace, B. M., Brown, W. E., **Stoichiometric composition of whitlockite,** *J. Dent. Res.* **50,** No. 2, 343-346 (Mar.-Apr. 1971).

Key words: calcification; calcium; dicalcium phosphate; octacalcium phosphate; pyrolysis; pyrophosphate; stoichiometry; whitlockite; β-tricalcium.

The mineral whitlockite has been described as having Ca/P ratios of 3:2 and 10:7. This study used the pyrolytic formation of pyrophosphate and whitlockite from calcium orthophosphates and their mixtures with $CaCO_3$ to determine this Ca/P ratio. Its mean value of 1.506±0.015 indicated a formula of $Ca_3(PO_4)_2$.

15997. Huebner, R. H., Bushnell, D. L., Jr., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Ultraviolet photoabsorption by halocarbons 11 and 12 from electron-impact measurements (Summary),** *Argonne Natl. Lab. Report No. ANL-75-60, Part I. Radiological and Environmental Research Annual Report on Fundamental Molecular Physics and Chemistry,* pp. 18-21 (Argonne National Laboratory, Argonne, IL, July 1974-June 1975).

Key words: electron energy loss; electron impact; halocarbon 11, $CFCl_3$; halocarbon 12, CF_2Cl_2; uv photoabsorption.

Electron energy loss measurements are made of Freons 11 and 12. The data is converted to oscillator strength distributions and compared to the existing photoabsorption data in the energy range relevant to atmospheric photodissociation.

15998. Huebner, R. H., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Apparent oscillator strengths for nitrous oxide (Summary),** *Argonne Natl. Lab. Report No. ANL-75-60, Part I. Radiological and Environmental Research Annual Report on Fundamental Molecular Physics and Chemistry,* pp. 3-6 (Argonne National Laboratory, Argonne, IL, July 1974-June 1975).

Key words: electron energy loss; N_2O; oscillator strengths; UV.

Energy loss spectra of N_2O were obtained in the 4 to 14 eV region and converted to oscillator strengths and compared to the optical values.

15999. Huebner, R. H., Celotta, R. J., Mielczarek, S. R., Kuyatt, C. E., **Apparent oscillator strengths for molecular oxygen, derived from electron energy-loss measurements (Summary),** *Argonne Natl. Lab. Report No. ANL-75-60, Part I. Radiological and Environmental Research Division Annual Report on Fundamental Molecular Physics and Chemistry,* pp. 1-2 (Ar-

gonne National Laboratory, Argonne, IL, July 1974-June 1975).

Key words: energy loss; O_2; oscillator strengths; oxygen; transition probabilities.

Oscillator strengths for O_2 from 6 to 14 eV are derived from the energy-loss spectrum of 100 eV incident electrons. Integrated f values for the Schumann-Runge bands and continuum, which span four orders of magnitude in intensity, agree well with high-resolution photoabsorption measurements.

16000. Jaeger, E. F., Oster, L., Phelps, A. V., **Growth of thermal constrictions in a weakly ionized gas discharge in helium,** *Phys. Fluids* **19,** No. 6, 819-830 (June 1976).

Key words: constrictions; gas discharge; helium; ionized gas; numerical solutions.

Neutral and charged particle densities, radial velocities, and temperatures are calculated as functions of time for cylindrical discharges in helium at pressures from 1 to 1000 torr and a radius of 1 cm. Ionization, recombination, ambipolar diffusion, specific heat of the neutrals, and variation of gas pressure in space and time are included. Ionization of excited states, energy loss by radiation, and space charge sheaths are neglected. Under most conditions, increased ionization in regions of decreased gas density causes a constriction of the discharge which is accentuated at high pressures and high recombination rates. Greater circuit resistance stabilizes the discharge. At low pressures, the electron density profile expands. Initial steep gradients in electron density cause constrictions off axis.

16001. Youden, W. J., **Evaluation of analytical data,** Chapter in *Encyclopedia of Industrial Chemical Analysis*, F. D. Snell and C. L. Hilton, Eds., **1,** Gen. Tech. A-4, 746-763 (Interscience Publ., New York, NY, 1966).

Key words: analytical data; analytical work; critical evaluation of an analytical procedure; industrial chemical analysis; interlaboratory comparisons; sampling error.

The material is expository and written for readers with little or no statistical background. The article covers the following topics: methods of reporting precision and accuracy, control charts for routine analytical work, critical evaluation of an analytical procedure, interlaboratory comparisons, and sampling error.

16002. Steiner, B. W., **Review of the CIE photometric model and of the status of radiometric measurements,** *Proc. Symp. on The Basis for Effective Management of Lighting Energy, Washington, DC, Oct. 29-30, 1976,* pp. 185-195 (Federal Energy Administration, Washington, DC, 1976).

Key words: CIE photometric model; photometry, heterochromic; radiometric measurements.

The paper reviews the status of the CIE photometric model and of radiometric measurements. The CIE photometric model universally used for heterochromatic photometry is an additive model, in contrast to the behavior of the eye in viewing large areas. Although this additivity is not valid visually, the practical advantages of such a system until now have outweighed the disadvantages. This situation should be reexamined. Moreover, the most careful spectral measurements now show a 2 percent spread in the visible, comparable to the best photometric measurements. Although routine commercial measurements cannot yet be expected to achieve this level of agreement, this goal for the future now seems realistic. On this basis, a more visually realistic photometry now seems to be the practical goal.

16003. Nimeroff, I., **Symposium on visual signaling,** *Appl. Opt.* **13,** No. 10, 2186, 2445-2446 (Oct. 1974).

Key words: colorimetry of signals; effective intensity of flashing lights; legibility of signs; visual signaling.

A symposium on visual signaling was held on April 9 and 10, 1974, in Washington, D.C. sponsored by CIE Committee TC 1.6, in cooperation with several agencies of the Department of Transportation. The symposium, attended by investigators from many parts of the world covered researchers on a wide variety of topics such as: 1. visibility of daytime and nighttime signals; 2. visibility and legibility of signs; 3. colorimetry of surface colors, particularly retroreflectors.

16004. Fong, J. T., **Energy approach for creep-fatigue interactions in metals at high temperatures,** *Trans. ASME J. Pressure Vessel Tech.* **97,** Series J, No. 3, 214-222 (1975).

Key words: creep; dissipation; elevated temperature; energy; hold-time; hysteresis; low-cycle fatigue; plasticity; stainless steel; stress relaxation; thermodynamics; viscoelasticity.

An analysis of the so-called creep-fatigue interactions in a reannealed AISI type 304 stainless steel with and without hold-time at 593 deg C (1100 deg F) is presented with a numerical example. The analysis is based on a series of papers on the thermodynamics of materials exhibiting both time-dependent and permanent-set behavior under mechanical and/or thermal loadings. Assuming isothermal loadings, the analysis consists of an "operational" decomposition of the total mechanical work into a stored part (long-term elasticity), and two dissipated parts, namely, an instantaneous component and a delayed component due to viscoelasticity. Each of the two dissipated components is again subdivided, operationally, into an "intrinsic" part (atomic diffusion and motion of dislocations), and a "structural" part (lattice strains and propagation of microcracks). The significance of the energy approach in unifying microscopic and macroscopic testing data and in formulating multi-axial design criteria for high-temperature components such as pressure vessels, turbine rotors, steam piping, etc., is discussed.

16005. Touloukian, Y. S., Kirby, R. K., Taylor, R. E., Desai, P. D., **Thermal expansion, metallic elements and alloys,** *Thermophysical Properties of Matter, Volume 12,* 1414 pages (Plenum Publishing Corp., New York, NY, 1975).

Key words: alloys; coefficients of thermal expansion; compilation; critical evaluation; elements; thermal expansion.

This volume of Thermophysical Properties of Matter comprises two major sections: the front text on theory and measurement together with its bibliography, and the main body of numerical data and its references. The main body of numerical data is the result of a comprehensive survey of the literature. The scope of coverage includes data on the thermal expansion of the metallic elements and alloys. All data were extracted directly from their original sources. The original data have been critically evaluated and analyzed and recommended reference values, provisional values or typical values are presented.

16006. Stiefel, S. W., **Procedural options for modification of architectural glass in residences to improve occupant safety,** *Proc. 24th Annual Conf. Standards Engineers Society, Syracuse, NY, Sept. 28-Oct. 1, 1975,* pp. 61-64 (Standards Engineers Soc. Inc., Minneapolis, MN, 1975).

Key words: architectural glass products; Consumer Product Safety Act; residence-related products; residential safety modification; safety implementation approaches.

The U.S. Consumer Product Safety Commission (CPSC) has the responsibility for developing and promulgating mandatory safety standards for products which pose unreasonable risks of

injury for consumers. One of the first products selected for development of a safety standard under the Consumer Product Safety Act of 1972 was architectural glass. The initial impact of the adoption of a mandatory standard for architectural glass would be rather limited, largely due to the fact that people will continue to occupy existing housing that will not be immediately subject to the new rule.

This paper discusses research in the Center for Consumer Product Technology at NBS conducted for the CPSC. The paper identifies alternative retrofit options intended to ameliorate the hazards associated with existing installed architectural glass, evaluates these options and postulates implementation approaches for consideration by the CPSC for encouraging safety modifications.

16007. Marvin, R. S., Sherwood, G. B., **A guide to sources of information on materials,** Chapter in *Handbook of Materials Science. Volume III: Nonmetallic Materials and Applications,* C. T. Lynch, Ed., pp. 603-627 (CRC Press, Inc., Cleveland, OH, 1975).

Key words: data centers; data tabulations; evaluated data; material properties; referral centers; sources of data.

A list of sources of data on properties of materials, plus guides to more extensive listings is provided. The individual data centers and publications listed are primarily those which attempt a critical evaluation of the reliability of the values cited.

16008. Yonemura, G. T., Kohayakawa, Y., **A new look at the research basis for lighting level recommendations,** *Proc. Symp. on The Basis for Effective Management of Lighting Energy, Washington, DC, Oct. 29-30, 1975,* pp. 151-183 (Federal Energy Administration, Washington, DC, 1976).

Key words: gratings; illuminating engineering; lighting; modulation transfer function; suprathreshold visibility; visibility; vision.

The validity of using threshold studies as the basis for lighting level recommendations is questioned. The performance of the eye at suprathreshold levels was investigated with sine- and square-wave gratings. The results indicate that the behavior of the eye is significantly different at suprathreshold levels as opposed to threshold levels. For threshold studies contrast is a monotonically decreasing function with respect to luminance. At suprathreshold levels the contrast function has a definite minimum, luminances greater or less requiring more contrast to appear subjectively equal. It is recommended that lighting levels be based on laboratory studies that appraise visual requirements and performance simulating conditions encountered in real world environments.

16009. Walleigh, R. S., **Controlled environments for meaningful measurement,** *Res. Develop. Mag.* **20,** No. 1, 16-21 (Jan. 1969).

Key words: engineering; environmental; interference abatement; laboratory environments; radiation; sound studies.

Highlights are presented showing how NBS goes to great lengths to apply architectural planning concepts as well as control measures involving special equipment, materials, and techniques in order to achieve optimum laboratory environments for its measurement operations. The significance of comprehensive knowledge and control of conditions such as temperature, light, electrical current, gravity, vibration, pressure, etc., for the Bureau's service to U.S. science and technology in a time of rapid change, is discussed.

16010. Hougen, J. T., **Second all-union symposium on high resolution molecular spectroscopy,** *Appl. Opt.* **14,** No. 1, 8-9 (Jan. 1975).

Key words: high resolution molecular spectroscopy; lasers; meeting report; Novosibirsk; pressure-broadened line shapes; Soviet Union; submillimeter waves.

The second All-Union Soviet Symposium on High Resolution Molecular Spectroscopy was held in Novosibirsk, USSR from 11-13 September, 1974. The meetings contained some invited and many contributed papers in the fields of laser construction and application, contact-transformed vibration-rotation Hamiltonians, pressure-broadened line shapes in the one-atmosphere region, and spectroscopic instrumentation. Eighty percent of the papers were delivered in Russian, but Westerners were provided with essentially individual interpreters.

16011. Weiss, G. H., Rubin, R. J., **The theory of ordered spans of unrestricted random walks,** *J. Stat. Phys.* **14,** No. 4, 333-350 (1976).

Key words: Abelian summation; ordered spans; random walks; stable distributions.

The spans of an n-step random walk on a simple cubic lattice are the sides of the smallest rectangular box, with sides parallel to the coordinate axes, that contains the random walk. Daniels first developed the theory in outline and derived results for the simple random walk on a line. We show that the development of a more general asymptotic theory is facilitated by introducing the spectral representation of step probabilities. This allows us to consider the probability density for spans of random walks in which all moments of single steps may be infinite. The theory can also be extended to continuous-time random walks. We also show that the use of Abelian summation simplifies calculation of the moments. In particular we derive expressions for the span distributions of random walks (in one dimension) with single step transition probabilities of the form $P(j) \sim 1/j^{1+\alpha}$, where $0 < \alpha < 2$. We also derive results for continuous-time random walks in which the expected time between steps may be infinite.

16012. Savage, B. D., **High-resolution profiles of the diffuse interstellar feature at 5780 Å,** *Astrophys. J.* **205,** No. 1, 122-135 (Apr. 1, 1976).

Key words: atomic processes, interstellar; matter, line profiles.

High-resolution profiles ($\Delta\lambda \approx 0.2$ Å) were obtained of the diffuse interstellar feature at 5780 Å in 18 heavily reddened stars with the Wisconsin echelle spectrograph at the Cassegrain focus of the Mayall 4m telescope. This feature is, in all cases, asymmetrical with its steep side being toward the blue. On attempting to match theoretical profiles to the observed λ5780 profile in HD 183143 we find that theoretical profiles for such processes as autoionization, predissociation, or preionization do not provide acceptable fits to the observational data, while good fits can be obtained for the extinction profiles provided by small ($r \approx 750$ Å), cold grains containing impurities that produce narrow no-phonon absorption lines. If λ5780 is in fact due to this latter process, then the asymmetry of the feature provides information on the sizes of interstellar grains, while the width provides information on the internal temperatures of grains. Significant differences in the feature asymmetry were noted for several stars, a result that can readily be explained as being due to small differences in the particle size in different galactic regions. Although changes in the width of the feature at 5780 Å were noted, it is difficult to decide if the variations are due to cloud motions, observational errors, or changes in grain temperatures. However, it is possible that the broad weak feature superposed on λ5780 is due to the same process that produces λ5780 but in hot ($T \approx 100$-200 K) grains situated near the stars being observed. It is concluded that a careful study of the profiles of the narrow diffuse interstellar fea-

tures may provide interesting information on the internal temperatures and geometrical characteristics of interstellar particles.

16013. Meissner, P., **Evaluation of techniques for verifying personal identity,** *Proc. ACM-NBS Fifteenth Annual Technical Symp., Gaithersburg, MD, June 17, 1976,* pp. 119-127 (Association for Computing Machinery, Washington, DC, 1976).

Key words: ADP security; computer networks; controlled accessibility; encryption; evaluation criteria; key; password; personal identification; terminals; verification.

The Privacy Act of 1974 imposes a number of requirements upon Federal agencies to prevent the misuse of information about individuals and to assure its integrity and security. Central to the implementation of the required safeguards is verification of the identity of individuals who are authorized to have access to computer systems and networks. A variety of techniques for verifying identity are currently emerging under the impetus of increased concern for security. This paper reviews some of the more promising techniques in terms of their applicability to computer security, and discusses the factors involved in evaluating these techniques. A set of evaluation criteria is presented. Considerations arising from imperfect operation of identification devices are explored. The paper also outlines precautions which should be included in a system as supplements to the identity verification process, such as auditing of system access, hostage alarms, and encryption.

16014. Bald, J. F., Jr., Sharp, K. G., MacDiarmid, A. G., **The isolation and characterization of pentafluorodisilane,** *J. Fluorine Chem. Short Commun.* **3,** 433-435 (1973/74).

Key words: base catalyzed decomposition; fluorodisilane; pentafluorodisilane; physical properties; pyrolysis; silicon difluoride.

The primary product of the reaction between hydrogen bromide and silicon difluoride, SiF_2, has been shown to be 1-bromo-1,1,2,2,-tetrafluorodisilane, SiF_2HSiF_2Br (I). This compound decomposes spontaneously at room temperature with pentafluorodisilane, Si_2F_5H (II) as the primary product. A more efficient source of (II) involves fluorination of the Si-Br bond in (I) with antimony trifluoride, SbF_3. Isolation of (II) can be effected by multiple runs on a low temperature distillation column.

The physical properties of (II) have been determined and are discussed, as are the infrared, ^1H and ^{19}F nmr and mass spectra.

The thermal stability and several chemical characteristics of (II) have also been investigated. Specific experiments which are discussed involve the pyrolytic and base-catalyzed decompositions of (II).

16015. Watson, R. E., Perlman, M. L., Herbst, J. F., **Core level shifts in the 3*d* transition metals and tin,** *Phys. Rev. B* **13,** No. 6, 2358-2365 (Mar. 15, 1976).

Key words: binding energy shifts; core level shifts; tin.

We present estimates of various contributions to the free-atom-metal binding-energy shifts, ΔE_B, for the 2*s* and 2*p* core levels of the iron series elements and, for comparison, the $3d_{5/2}$ level of Sn. Our results indicate that the sharp break in the experimental ΔE_B values occurring between Ni and Cu is due to variation in differences of *d*-electron count, i.e., *d* configuration, between atom and metal. Ley *et al.* who neglected the *d*-configuration differences, attributed the break in ΔE_B to a change in extra-atomic screening. Through free-atom calculations we find extra-atomic screening energies of 6-8 eV for Ti through Zn, with no break between Ni and Cu, and ~10 eV for Sn. In conjunction with charge-renormalization and dipole-term estimates, these results suggest that intra-atomic screening of core holes in metals is an important factor influencing free-atom-metal binding-energy shifts.

16016. Vorburger, T. V., Waclawski, B. J., Sandstrom, D. R., **Improved microwave-discharge source for uv photoemission,** *Rev. Sci. Instrum* **47,** No. 4, 501-504 (Apr. 1976).

Key words: adsorption; chemisorption; CO; cyclotron resonance; electron cyclotron resonance; magnetic field; microwave discharge; photoemission; tungsten; ultraviolet photoemission.

A microwave-discharge uv light source has been improved to yield significant photon fluxes at 26.9 and 40.81 eV. In order to optimize the 26.9-eV (Ne II) and 40.81-eV (He II) radiation, the discharge was operated at ~2.5 Pa (0.019 torr) in an external constant magnetic field of ~0.070 T (700 G), which, together with the oscillating electric field of the cavity, produces electron cyclotron resonance. When the discharge conditions were optimized for production of 40.81-eV photons, features near the Fermi energy in the photoemission distribution from W(100) for 40.81-eV photons are approximately 6 percent as intense as the corresponding features in the distribution for 21.22-eV photons. We estimate that under these conditions the flux of 40.81-eV photons is roughly 50 percent of the flux of 21.22-eV photons. Photoemission energy distributions with $h\nu$=16.85, 21.22, 26.9, and 40.81 eV have been measured for saturated exposures of CO on W(100) at a temperature of ~80 K. The variation in these data with photon energy is important for making orbital assignments to the energy levels of adsorbed molecular CO.

16017. McBee, C. L., Kruger, J., **Ellipsometric spectroscopic study of breakdown of Fe-Cr and Fe-Cr-Mo alloys,** *Proc. USA-Japan Seminar on Passivity and Its Breakdown on Iron and Iron Base Alloys, Honolulu, HI, Mar. 10-12, 1975,* pp. 131-132 (National Association of Corrosion Engineers, Houston, TX, 1976).

Key words: ellipsometric parameters; ellipsometric spectroscopy; iron base alloys; iron single crystal.

Ellipsometric spectroscopy was recently applied to the study of the breakdown of passivity on pure iron single crystal surfaces. These studies first obtained a measurement of the ellipsometric parameters, Δ and ψ, as a function of wavelength for a passivated surface held at a potential in a buffered borate solution. Cl^- ions were then added, and it was noted for most wavelengths that no changes were found for Δ and ψ as a function of time during the induction period prior to breakdown. However, at a few wavelengths, Δ and ψ did vary with Cl^- additions. Using these changes and current measurements, it was possible to study events leading to the breakdown of Fe. The work described here extends the technique employed in previous studies to Fe-Cr-Mo alloys.

16018. Kruger, J., **Chemical breakdown of passivity,** *Proc. USA-Japan Seminar on Passivity and Its Breakdown on Iron and Iron Base Alloys, Honolulu, HI, Mar. 10-12, 1975,* pp. 91-98 (National Association of Corrosion Engineers, Houston, TX, 1976).

Key words: chemical breakdown; chloride ion; corrosion; ferrous alloys; localized corrosion; passivity.

A review is given of the various theoretical models for the chemical breakdown of passivity. The models discussed are adsorbed in displacement, ion migration, or penetration and chemico-mechanical breakdown. The models are then related to data in the literature on breakdown initiation kinetics, critical potentials for breakdown, and alloy composition and structural and environmental factors. Based on the above examination a

number of critical questions are posed that must be answered in order to understand chemical breakdown of the passive film.

16019. Moore, R. T., **The influence of ink on the quality of fingerprint impressions,** *Proc. Conf. on the Science of Fingerprints, London, England, Sept. 24-25, 1974,* pp. 69-84 (1974).

Key words: film thickness; film uniformity; fingerprint impressions; fingerprint readers; image quality; ink films; lubricity.

Tests were conducted on several types of ink to determine their influence on the quality of fingerprint impressions which they could produce. The thickness and uniformity of the film used to ink the fingers were found to be the most significant factor in providing high quality impressions. A method is described for metering out printer's ink and estimating whether or not a uniform film of near optimum thickness has been rolled out on a glass inking plate.

16020. Wehrli, R., Bryan, J., **Assemblage: A process-oriented teaching method,** *AIA J.*, pp. 75-77 (May 1976).

Key words: architectural-design teaching; assemblage; design critiques; feedback; teaching method.

Architecture for the future—with material shortages, environmental protection, and new technological possibilities—cannot be accommodated by traditional methods of design education. A new teaching method called assemblage, with feedback advantages, allows students to assemble special blocks to create designs while their instructor, using a scorecard, evaluates progress against fixed criteria which the student understands. Because design problems are increasingly complex with multiple criteria to satisfy at early stages of design, the assemblage method is needed. It allows students to take multiple fixed criteria into consideration and the instructor to keep track of all design criteria while giving students immediate, analytical feedback on how well they are doing. With assemblage's design blocks and analytical scorecards, an instructor can assign simulation of real-world design problems, supply feedback from an analytical scorecard to encourage future improvement in design in less than an hour for each trial scheme. A 1968 experiment in assemblage demonstrated students learned perceptibly during six trials when given feedback (critiques), but learning was marginal when feedback was withheld.

16021. Mangum, B. W., Wood, S. D., **Reliability of temperature measurements and control provided in clinical instruments (Abstract),** *Proc. 28th Annual Conf. Engineering in Medicine and Biology, New Orleans, LA, Sept. 20-24, 1975,* p. 251 (1975).

Key words: clinical instruments; instruments, clinical; temperature measurements.

Some medical and clinical instruments rely heavily on accurate temperature measurements. Thermistors are often used in these instruments although little is known about their behavior on ageing or thermal cycling. Results of an NBS study on ageing of six types of thermistors are presented.

16022. Zalubas, R., Hagan, L., **Atomic energy levels of rare earth elements,** *Proc. 11th Rare Earth Research Conf., Traverse City, MI, Oct. 7-10, 1974,* **1,** 411-416 (1974).

Key words: atoms; classification; energy levels; ions; rare earths; spectroscopy.

At the National Bureau of Standards members of the Spectroscopy Section are investigating rare earth spectra and are working on a critical compilation of rare earth energy levels. Also a number of people in other laboratories are working on these spectra. The compilation will include all experimentally known levels of free atoms and ions of lanthanum through lutetium (Z=57 – 71).

16023. Yates, J. T., Jr., Erickson, N. E., Worley, S. D., Madey, T. E., **The use of x-ray photoelectron spectroscopy (ESCA) for studying adsorbed molecules,** Chapter in *The Physical Basis for Heterogeneous Catalysis,* E. Drauglis and R. I. Jaffee, Eds., pp. 75-105 (Plenum Press, New York, NY, 1975).

Key words: carbon monoxide; chemisorption; ESCA; extra-atomic relaxation; formaldehyde; oxygen; photoelectron spectroscopy; physisorption; tungsten; xenon; XPS.

An ultrahigh vacuum x-ray photoelectron spectrometer has been used to study a number of cases of adsorption on tungsten single crystals. The choice of adsorbates spans a wide range from dissociative chemisorption to nondissociative chemisorption to physisorption.

A method for estimating absolute surface coverages from ESCA data has been verified by comparison with absolute molecular-beam measurements of monolayer coverage for the system oxygen+W(100).

The ESCA technique for measuring chemical shifts has been found to be useful in discriminating various modes of surface bonding in all adsorption systems studied. For oxygen chemisorbed on W(100), two distinct oxygen states are seen. In the case of CO chemisorbed on W(100), a direct correlation between ESCA and thermal desorption behavior has been observed for four states of chemisorbed CO. For H_2CO interaction with W(100), dissociative adsorption occurs initially, followed by multilayer condensation of H_2CO. For xenon physisorption on W(111), high-energy sites (defects?) are covered first by mobile xenon; this is followed by adsorption on the uniform surface.

Coverage-dependent shifts in binding energy have been observed in several cases. The magnitudes of these shifts are independent of changes in average work function, and are best explained by considering local dipole interactions.

In all cases studied, it appears that final-state extra-atomic relaxation effects dominate in determining the magnitude of the chemical shift for adsorbed species. Core-level binding energies have been found to decrease upon adsorption in all cases so far studied, and the magnitude of the decrease seems to correlate in a crude way with increasing strength of adsorption.

16024. Yahalom, J., Ives, L. K., **Electron-microscopical studies of passive films on stainless steels,** *Proc. USA-Japan Seminar on Passivity and Its Breakdown on Iron and Iron Base Alloys, Honolulu, HI, Mar. 10-12, 1975,* pp. 69-71 (National Association of Corrosion Engineers, Houston, TX, 1976).

Key words: electron microscopy; Fe-Cr alloys; passive films; pitting corrosion; stainless steel; x-ray analysis.

Transmission electron microscopy and diffraction were employed to study *in situ* films over corrosion pits in ferritic Fe-Cr alloys containing 5, 12, and 19 wt.% Cr and in commercial AISI 304 and 316 stainless steels. The composition of passive films extracted from the pits was obtained by energy dispersive x-ray emission analysis. In all cases an enhanced concentration of Cr was observed, though to a lesser extent in the Fe-5% Cr alloy. A substantial difference in the crystalline structure and morphology was found to exist among the various alloys. The differences in passivity exhibited by the alloys and the mechanism of breakdown are discussed in light of these findings.

16025. Cotton, I. W., Benoit, J. W., **Prospects for the standardization of packet-switched networks,** (Proc. Fourth Data Communications Symp., Quebec City, Canada, Oct. 7-9, 1975), Paper in *Network Structures in an Evolving Operational Environ-*

ment, IEEE Catalog No. 75 CH1001-7 Data, pp. 2-1 –2-7 (The Institute of Electrical and Electronics Engineers Inc., New York, NY, 1975).

Key words: computer networks; data communications; networks; packet-switching; standards.

The technology of packet-switching is now moving rapidly toward commercial application as a number of companies in the U.S. and abroad are preparing to offer service. However, there does not appear to be much commonality of design in these various commercial systems. Standards are needed to facilitate the possible use of multiple networks by individual users and the eventual interconnection of local or regional networks.

This paper reviews the technical issues relevant to the standardization of packet-switched networks. This is accomplished through narrative and model of a packet-switched system which clarifies the various functions of the system. Each of the possible candidate areas for standards is discussed in terms of the likelihood that standards can be developed.

16026. Wang, F. W., **Frictional properties of dilute block-copolymer solutions and homopolymer solutions. Application to molecular weight determination,** *Macromolecules* **9,** No. 1, 97-101 (Jan.-Feb. 1976).

Key words: bead-spring model; block copolymers; dilute polymer solutions; limiting viscosity number; Mandelkern-Flory-Scheraga equation; molecular weight determination; sedimentation coefficient; translational diffusion coefficient; Zimm theory.

An equation for the translational diffusion coefficient of block copolymers in dilute solution has been obtained by modifying Zimm's equation for homopolymers to take into account the existence of dissimilar segments in block copolymers. Illustrative calculations for homopolymers and block copolymers have been made and the results for homopolymers have been compared with experiments and with the calculations of Yamakawa and Fujii. A procedure has been proposed to determine the molecular weight of a block copolymer from measurements of its limiting viscosity number and its sedimentation coefficient or translational diffusion coefficient.

16027. Wright, J. R., **Opening remarks by the session chairman,** (Proc. 6th Congress on The Impact of Research on the Built Environment, Budapest, Hungary, Oct. 2-8, 1974), Chapter in *Congress Book II, 60-61 (Conseil International du Batiment Pour la Recherche, L'Etude et la Documentation, Rotterdam, The Netherlands, 1974).*

Key words: building construction; building design; building materials; building research; environmental protection; international cooperation; international standards; materials conservation; materials science; performance concept.

The design of buildings is ultimately limited by the availability and properties of building materials. Materials are not only significant to the built environment in their own right but figure in a cluster of interrelated trends – world competition for resources, materials conservation, materials substitution, environmental protection, application of the performance concept to building, and materials science. Against these pressures and dynamics, growing international cooperation is discerned among building technologists, cooperation which in part is reflected by an increasing body of international standards for building materials.

16028. Van Zyl, B., Chamberlain, G. E., Dunn, G. H., Ruthberg, S., **Definitive pressure generation in the 10^{-4}-10^{-3} torr range for atomic scattering experiments,** *J. Vac. Sci. Technol.* **13,** No. 3, 721-727 (May/June 1976).

Key words: pressure generation; 10^{-3} to 10^{-4} torr range.

A pressure generation technique using the dynamic expansion method is described. Measurements and uncertainties are discussed, and it is shown that the method provides a convenient means for obtaining accurate pressures in the 10^{-3}-10^{-4} torr range. High confidence uncertainties as low as about ±1 percent are achieved.

16029. Heydemann, P. L. M., **Ultrasonic measurements at pressures up to 50 kbar,** *Proc. Intern. Colloq. Les Propriétés Physiques des Solides Sous Pression, Grenoble, France, Sept. 8-10, 1969,* No. 188, pp. 461-467 (Centre National de la Recherche Scientifique, Paris, France, 1970).

Key words: bulk modulus; equation of state; high pressure; phase transitions; potassium chloride; ultrasonics.

Ultrasonic measurements as a function of pressure or temperature provide one of the most accurate means to determine pressure or temperature dependence of the bulk modulus and the density of both liquids and solids. Such measurements are currently carried out with very high accuracy at pressures up to about 4 kbar (1 kbar=10^8N/m^2) in several laboratories.

If the material under investigation undergoes transitions at higher pressures, or if the bulk modulus is noticeably nonlinear with pressure, ultrasonic measurements at pressures higher than 4 kbar are needed. This report describes our methods to carry out such measurements at pressures close to 50 kbar, both under hydrostatic and nonhydrostatic conditions.

For most materials the accuracy of the density and bulk modulus data obtained from such measurements is much higher than that obtained from isothermal dilatometric measurements. In the case of tellurium, the accuracies for the bulk modulus at 30 kbar are 1.6 and 23 percent, respectively.

Another interesting application of ultrasonics at high pressures is the detection of phase transitions and the measurement of the elastic properties as the material undergoes the transition. As an example for measurements through a transition range, our results of ultrasonic and isothermal dilatometric measurements on KCl are presented. We find that the ratio of specific heats also shows a sharp increase in the transition range.

16030. Wegstein, J. H., **The automated classification and identification of fingerprints,** *Proc. Conf. on the Science of Fingerprints, London, England, Sept. 24-25, 1974,* pp. 49-67 (1974).

Key words: classification; computer; fingerprint; identification; pattern recognition; scanner.

Data read by the FBI's FINDER automatic fingerprint reader system must undergo three processing steps in order to achieve fingerprint identifications. First, the data must be "registered" to a standard reference position for subsequent comparison purposes. Next, the data are "classified" into suitable categories for filing and retrieval purposes. Finally, the data are "matched" against other fingerprint data of the same classification by comparing their distinctive minutiae. Computer algorithms for these processing steps are discussed and representative results presented.

16031. Haisch, B. M., Linsky, J. L., **Properties of the chromosphere-corona transition region in Capella,** *Astrophys. J.* **205,** No. 1, L39-L42 (Apr. 1, 1976).

Key words: stars, chromospheres; stars, late type; ultraviolet, spectra.

Analysis of recent ultraviolet observations of the Capella binary system (α Aur) indicates a dense, geometrically narrow chromosphere-corona transition region in the Capella system

primary (G5 III) similar in many respects to a solar active region. An examination of the coronal energy balance, together with the coronal base pressure derived from the line fluxes, predicts a corona with a mean temperature of 1.2×10^6 K and a large stellar wind consistent with observations.

16032. Beitler, S. R., Armstrong, G. T., Domalski, E. S., Keane, T. R., Eds., **Book, Combustion Fundamentals for Waste Incineration,** 217 pages (The American Society of Mechanical Engineers, New York, NY, 1974).

Key words: combustion thermodynamics; enthalpies of formation; incinerators, industrial; thermodynamic data; waste disposal.

This monograph contains tabulated thermodynamic data for over 1300 substances needed by engineers for design and operation of incinerators for industrial wastes. In addition to tables of data, the monograph provides definitions of thermodynamic terms and a brief discussion of practical thermodynamic functions, a discussion of the calculation of thermochemical quantities related to combustion, and a brief discussion of the effect of temperature upon combustion processes and reaction equilibria. The monograph also contains annotated bibliographies containing selected references to (1) supplementary sources of thermodynamic information on chemical substances and materials, (2) methods of estimation of thermodynamic data, and (3) combustion and high temperature reaction equilibria. The principal table gives enthalpies of formation at 298.15 K for 989 organic compounds and inorganic carbon compounds listed in order of increasing empirical formula, and is accompanied by a name-formula index as an additional aid to locating data. Two other tables give enthalpies of formation at 298.15 K of 285 inorganic oxides and 39 organic polymers for which a reasonable formula could be assigned. An appendix at the end of the monograph gives supplementary information such as symbols for thermodynamic quantities, definitions of the SI base units, physical constants, and atomic weights.

16033. Burnett, E. D., **NBS hearing aid test procedures, Chapter III. Performance measurement data from the National Bureau of Standards,** *Handbook of Hearing and Measurement 1976,* **IB 11-52,** pp. 14-299 (Veterans Administration, Washington, DC, 1976).

Key words: anthropometric manikin; free-field measurements; hearing aid tests; orthotelephonic response.

This report discusses the current test procedures used by NBS to evaluate the electroacoustic properties of hearing aids. It includes the technical and practical reasons for performing the various tests in the manner described and in certain cases presents ideas and preliminary test methods for the evaluation of special-purpose hearing aids. However, the specific details of the electronic equipment used to perform the tests are not described.

16034. Evans, A. G., Johnson, H., **The fracture stress and its dependence on slow crack growth,** *J. Mater. Sci.* **10,** 214-222 (1975).

Key words: analytical predictions; constant stress rate; empirical measurements; fracture stress; slow crack growth.

An analysis is presented which enables the fracture strength, (under constant stress-rate conditions) to be predicted from fracture mechanics data obtained during slow crack growth—by identifying and evaluating several key parameters. The predicted strength characteristics are illustrated using fracture mechanics data obtained for a soda lime silicate glass. Finally, the predicted strengths are compared with strengths measured in flexure on abraded soda lime silicate glass specimens. A good correlation is obtained, indicating an equivalence between micro- and macrocrack propagation conditions for this material.

16035. Epstein, G. L., Reader, J., **Resonance lines and energy levels of Cs III, Ba IV, and La V,** *J. Opt. Soc. Am.* **66,** No. 6, 590-598 (June 1976).

Key words: barium; cesium; lanthanum; spectra; ultraviolet; wavelengths.

The spectra of Cs III, Ba IV, and La V have been observed in a sliding spark discharge on the 10.7 m normal-incidence vacuum spectrograph at NBS. Analysis of the observations of Cs III and La V has yielded the energy levels of the $5s^25p^5$ and $5s5p^6$ configurations and nearly all levels of the $5s^25p^45d$ and $5s^25p^46s$ configurations that can combine with the $5s^25p^5\ ^2P^\circ$ ground term. The observations for Ba IV have yielded the levels of the $5s^25p^5$ and $5s5p^6$ configurations. The $5s^25p^45d + 5s^25p^46s + 5s5p^6$ levels of Cs III and La V have been theoretically interpreted, with configuration interaction included. The energy parameters determined from a least-squares fit to the observed level values are compared with Hartree-Fock calculations. The ionization energies are found to be 33.38 ± 0.25 eV for Cs III, 47.1 ± 0.6 eV for Ba IV, and 61.6 ± 0.6 eV for La V. By extrapolating these values the ionization energy of Ce VI is estimated as 77.6 ± 1.2eV.

16036. Albus, J. S., Evans, J. M., Jr., **A hierarchical structure for robot control,** *Proc. 5th Int. Symp. on Industrial Robots, Chicago, IL, Sept. 22-24, 1975,* pp. 231-238 (Society of Manufacturing Engineers, Dearborn, MI, 1975).

Key words: automatic control; automation; robots.

Sophisticated control of a mechanical manipulator is similar in many respects to the problem of organizing coordinated activity in any complex system with many degrees of freedom. It requires that the overall control problem be partitioned into manageable subproblems which can be arranged in a hierarchical control structure. At each level in the control hierarchy there exists a computing device or algorithm capable of accepting input commands from the next higher level, combining these with appropriate feedback signals from the controlled environment, and responding with an ordered sequence of output commands to the next lower level. Input to the top of the hierarchy commits the entire system to a specific goal-directed activity. Output from the bottom consists of strings of signal voltages which drive individual joint activators.

NBS has been evaluating ways in which such a hierarchical control structure can be implemented. One implementation is the Cerebellar Model Articulation Controller (CMAC), a memory-driven control element which can be used at each level in the control hierarchy to accept input commands from higher levels under feedback control. CMAC is a general purpose adaptive control function computer which can cope with many nonlinear feedback variables simultaneously, such as measurements of misalignment of parts, variable mass loading, irregularities in materials, and constraints imposed by an external environment.

NBS research in sensors and computer control systems will be described, with specific examples of applications for hierarchical control systems.

16037. McBee, C. L., Hastie, J. W., **Mechanistic studies of phosphorus containing flame retardants,** *Proc. 1975 Int. Symp. on Flammability and Fire Retardants, Montreal, Canada, May 22-23, 1975,* pp. 253-263 (Technomic Publication Co., Inc., Westport, CT, 1976).

Key words: flame retardancy; mass spectrometry; optical spectroscopy; phosphorus; polyester.

A combination of mass spectrometric and optical spectroscopic studies has been made to establish a mechanism for

phosphorus controlled flame retardancy in thermoplastics. It is shown that a vapor phase mode of flame inhibition can account for the known flame retardancy effect of triphenylphosphine oxide in polyester substrates.

16038. Bagg, T. C., **A technological review: The future of microimagery in the library,** *Drexel Lib. Quart.* **11,** No. 4, 66-74 (Oct. 1975).

Key words: computer output microforms; information storage and retrieval; libraries; microfilm; microforms; micrographics.

Libraries are using microforms in a variety of ways and will add many more to their collections to save space, have available out-of-print materials, expand audiovisual materials and as the result of computer-generated microforms of frequently updated indexes, catalogs, listings, etc.

Despite the growing need of micrographic equipment, the libraries do not offer a large enough market to have equipment designed and produced by their specific needs. Libraries must therefore depend upon developments for other applications, some of which are discussed.

16039. Evans, A. G., Fuller, E. R., **Proof testing—The effects of slow crack growth,** *Mater. Sci. Eng.* **19,** No. 1, 69-77 (1975).

Key words: failure probabilities; lifetime assurance; proof testing; slow crack growth; unloading.

When slow crack growth occurs during proof testing, the extent of the crack growth while unloading from the proof stress has a substantial effect on the minimum predicted in-service failure time. It is essential that this crack growth is minimized to achieve effective failure prediction. Analyses are presented which show that the detrimental effects can be negated by environmental control during proof testing and/or rapid unloading from the proof stress; the requisite combination of unloading rate and environmental control is determined separately for each system.

16040. Henderson, M. M., **Copyright impacts of future technology,** (Proc. Symp. Centennial Meeting of the American Chemical Society, New York, NY, Apr. 5, 1976), *J. Chem. Inf. Comput. Sci.* **16,** No. 2, 72-74 (May 1976).

Key words: bibliographic data files; communications technology developments; computer developments; COM systems extension; copyright protection; facsimile transmission extension; photocopying; reprography developments.

Dynamic developments in computer and communication technologies, and in reprography and micrographics, are yielding systems and equipment that render better and faster access to information that has been copyrighted in traditional formats. Procedures and mechanisms must be worked out to permit us to take advantage of these technologies without destroying our basic systems of information dissemination.

16041. VanderHart, D. L., **Characterization of the methylene ^{13}C chemical shift tensor in the normal alkane n-$C_{20}H_{42}$,** *J. Chem. Phys.* **64,** No. 2, 830-834 (Jan. 15, 1976).

Key words: alkane; chemical shift tensor; methylene; NMR; ^{13}C.

^{13}C NMR chemical shifts in a single crystal of n-eicosane (n-$C_{20}H_{42}$) have been measured using the method of high power proton decoupling and the chemical shift tensors were characterized. Principal values in ppm relative to CS_2 are: (a) For CH_3: $\sigma_{11}=166.7\pm2$, $\sigma_{22}=171.2\pm2.0$, $\sigma_{33}=189.8\pm2$; (b) For the α-methylene: $\sigma_{11}=156.0\pm2.5$, $\sigma_{22}=163.1\pm2.5$, $\sigma_{33}=178.0\pm2.5$; and (c) For the interior methylenes: $\sigma_{11}=142.6\pm2.0$, $\sigma_{22}=154.6\pm2.0$, $\sigma_{33}=175.6\pm2.0$. From x-ray studies, only the unit cell parameters are known. On the basis of isolated molecule symmetry considerations, cross-polarization rate studies, and oriented polyethylene spectra, the interior methylene chemical shift tensor is assigned with respect to molecular orientation. The crystallographic axes are also related to the interior methylene chemical shift tensor and a prediction is made for the $C-CH_3$ bond direction relative to these crystallographic axes. The principal axes of the α-CH_2 and the CH_3 chemical shift tensors do not coincide with any bond directions. The difference (5.6 ppm) between the interior methylene average chemical shielding in solid n-eicosane and the isotropic liquid value is also discussed.

16042. Norden, B. N., **National measurement system: Length and related dimensional measurements—A micro study,** *NCSL Newsletter* **15,** No. 2, 21-26 (June 1975).

Key words: dimensional measurements; length measurements; National Measurement System.

Studies of the National Measurement System are currently in progress at the National Bureau of Standards. These studies are an attempt to understand the infrastructure and impact of measurement throughout our economy. One particular micro study is entitled *Length and Related Dimensional Measurements.* This brief article gives an overview of the developments to date; i.e., description of the infrastructure, identification of various users, and discussion of needed future research in the area of length and related dimensional measurements.

16043. Hamer, W. J., **Standard cells,** Chapter in *The Primary Battery,* G. W. Heise and N. C. Cahoon, Eds., **I,** 433-477 (John Wiley & Sons, Inc., New York, NY, 1971).

Key words: batteries; cells, primary; dry cells; primary batteries; primary cells.

Testing procedures for primary cells and batteries are outlined. Emphasis is given to cells and batteries of the dry type. Tests are classified as (1) general tests, (2) initial tests, (3) service tests, and (4) shelf tests. Under initial tests measurements of open-circuit voltage, initial closed-circuit voltage, flash or short-circuit current, and internal resistance (or impedance) are considered. Methods that may be used to measure internal resistance are considered at length. Service tests include 28 standard tests as well as some other types of tests still in use. Some special tests as well as tests for wet primary cells and reserve batteries are briefly considered.

16044. Wets, R. J. B., Witzgall, C., **Towards an algebraic characterization of convex polyhedral cones,** *Numer. Math.* **12,** 134-138 (1968).

Key words: algebraic; cones; faces; Jordan-equivalent; matrices; polyhedral.

It is shown that the theory of positive linear independence and the properties of Jordan-equivalent matrices can be utilized effectively in order to obtain an algebraic characterization of a face structure of convex polyhedral cones.

16045. Pyke, T. N., Jr., **Assuring user service quality in a distributed computer network,** *Proc. COMPCON 76 Spring, San Francisco, CA, Feb. 24-27, 1976,* pp. 73-76 (IEEE Computer Society, Washington, DC, 1976).

Key words: computer networking; distributed networks; network service.

As users become dependent on service from multiple computer systems within distributed computer networks, a variety of

problems arise in assuring that end user service quality is maintained. In this paper, a number of factors associated with user service quality are examined in the context of this trend toward distributed computing.

16046. Durig, J. R., Lafferty, W. J., Kalasinsky, V. F., **Spectra and structure of small-ring molecules. 33. Microwave spectrum of silacyclopentane,** *J. Phys. Chem.* **80,** No. 11, 1199-1202 (1976).

Key words: dipole moment; microwave spectrum; molecular structure; silacyclopentane; small-ring molecule; Stark effect.

The microwave spectrum of silacyclopentane, 1-silacyclopentane-*1,1-d_2*, and silacyclopentane-^{29}Si has been investigated in the spectral range of 8-40 GHz. The rotational lines of five vibrational excited states of the ring-puckering mode have also been assigned and are consistent with a high barrier to pseudorotation. Both the dipole moment measurements and the isotopic data indicate that the skeletal ring of this molecule is in the "twisted" C_2 conformation for the ground state. The *a* component of the dipole moment is 0.726 ± 0.005 D and the *c* component has been determined to be less than 0.01 D with a $|\mu_t| = 0.726 \pm 0.006$ D. The isotopic data are sufficient to determine the following parameters: $\angle HSiH = 108.76 \pm 0.26$, $r(Si-H) = 1.478 \pm 0.004$. Other important structural features have been estimated.

16047. Albus, J. S., Evans, J. M., Jr., **Robot systems,** *Sci. Am.* **234,** No. 2, 77-86B (Feb. 1976).

Key words: artificial intelligence; automation; computer control; manipulators; robots; robot systems.

This article reviews currently available industrial robots and research on robot systems. A hierarchical control structure concept, which is the basis for NBS research efforts in computer control systems, is used to provide a framework for this review.

16048. Branstad, M. A., Branstad, D. K., Jeffery, S., **Terminals: Out of sight but under control,** *Proc. COMPCON 74, San Francisco, CA, Feb. 26-28, 1974,* pp. 53-55 (IEEE Computer Society, Washington, DC, 1974).

Key words: security; terminals.

General purpose terminals, point-of-sale terminals, and cash dispensing terminals are described with respect to their common, as well as individual, security needs. Solutions which satisfy some terminal security requirements and needs for future security enhancements are presented.

16049. LeVanda, C., Bechgaard, K., Cowan, D. O., Mueller-Westerhoff, U. T., Eilbracht, P., Candela, G. A., Collins, R. L., **Bis(fulvalene)diiron, its mono- and dications. Intramolecular exchange interactions in a rigid system,** *J. Am. Chem. Soc.* **98,** No. 11, 3181-3187 (May 26, 1976).

Key words: biferrocenylene; delocalization; intramolecular exchange; magnetic susceptibility; mixed valence; Mössbauer spectra; optical.

Biferrocenylene [bis(fulvalene)diiron, BFD] was synthesized by two independent routes: an Ullman coupling of dibromoferrocene and the reaction of the fulvalene dianion with ferrous chloride. It was chemically oxidized to the mixed valence monocation and to the dication. These derivatives were characterized by optical, Mössbauer, ESR, and x-ray photoelectron spectra and magnetic susceptibility. The Mössbauer spectra of the mixed valence salts at 298 and 77 K indicate that both iron atoms are equivalent. X-ray photoelectron spectra similarly attest to this equivalence. An asymmetry in the intensity of the Mössbauer lines is due to a Karyagin effect. The Mössbauer spectrum of the dication shows a quadrupole splitting of 3.0 mm/s which is unusually large for a ferrocenium-type derivative. The magnetic susceptibility of BFD (2,3) picrate, measured in the 2-300 K range, follows a Curie law with a room temperature moment very close to the spin-only value. The dicationic fluoroborate salt is diamagnetic. The ESR spectra of the monocationic picrate and fluoroborate salts are characterized by narrow lines and a small rhombic anisotropy. An absorption in the near-infrared centered at 1550 nm is observed in the spectra of the monocations, but not the neutral or dicationic derivatives. The assignment of this band is discussed with respect to the results of the other physical measurements.

16050. Ferraris, J. P., Finnegan, T. F., **Electric susceptibility and d.c. conductivity of crystalline TTF–TCNQ,** *Solid State Commun.* **18,** Nos. 9/10, 1169-1172 (1976).

Key words: d.c. conductivity; microwave conductivity; organic conductors; thermal expansion; TTF–TCNQ.

An experimental study has been made of the intrinsic d.c. and microwave conductivity of "high purity" crystalline TTF–TCNQ. The maximum normalized peak conductivity in each case was found to be about 50 times the room temperature value. The cavity perturbation technique, used to determine the microwave conductivity and low temperature dielectric constant, is also shown to be a useful contactless method for measuring the thermal expansion.

16051. Chang, T. T., Cohen, M. I., **Paramagnetic resonance of Dy^{3+} in CdF_2,** *J. Chem. Phys.* **64,** No. 12, 5255-5260 (June 15, 1976).

Key words: CdF_2; Dy^3; paramagnetic resonance.

Paramagnetic resonance of Dy^{3+} substitutional for Cd in CdF_2 was observed at 24 GHz and 4.2 K. The cubic spectrum and the orthorhombic spectrum of samples cross doped with Li, Na, or K were studied. The *g* factors are as follows: for the Γ_7 transition, $g = 7.4250$; for Γ_8 transitions in cubic symmetry, $g = 2.4514$; and for Γ_8 transitions in orthorhombic symmetry, $g_{110} = 2.1025$, $g_{001} = 8.6613$, and $g_{110} = 10.1846$.

16052. Mihalas, D., Shine, R. A., Kunasz, P. B., Hummer, D. G., **Resonance-line transfer with partial redistribution. VIII. Solution in the comoving frame for moving atmospheres,** *Astrophys. J.* **205,** No. 2, 492-498 (Apr. 15, 1976).

Key words: line formation; radiative transfer; stars: chromospheres.

An analysis of the effects of partial frequency redistribution in the scattering process for lines formed in moving atmospheres has been performed using a flexible and general method which allows solution of the transfer equation in the comoving frame of the gas. As a specific example, we consider the same chromospheric and atomic model, with the same velocity field, that was studied by Cannon and Vardavas. We find that the large changes in the profiles obtained by those authors, between the cases of complete and partial redistribution are *spurious effects of angle-averaging in the observer's frame instead of the comoving frame.* Our results support fully the conclusion by Magnan that these changes are, in fact, unreal, at least for this particular model and redistribution function. Future work with other redistribution functions and with nonmonotone velocity fields will be possible using the techniques developed in this paper.

16053. Stevens, M. E., **Compatibility problems of network interfacing,** *Proc. Conf. on Interlibrary Communications and Information Networks, Warrenton, VA, Sept. 28-Oct. 2, 1970,* pp. 202-212 (American Library Association, Chicago, IL, 1971).

Key words: common practices; communication; compatibility; convertibility; information interchange; information networks; interfacing; interlibrary communication; man-machine interaction; network protocols.

The compatibility and convertibility problems of network interfacing are considered in the light of applicable standards, preferred common practices, and protocols. There is considerable emphasis upon requirements for interaction and information interchange. Specific technological problems of compatibility or convertibility at the interfaces between machine and machine, man and machine, and man and man are discussed. Promises for solution to at least the more tractable of the interfacing problems appear to lie in the growing conspicuity of these problems, the recognition of the need for compromise, a growing commitment to the usage of machines as aids to man, and the increasing impetus to cooperative action.

16054. Duff, J. W., Truhlar, D. G., **Classical *S* matrix: Application of the Bessel uniform approximation to a chemical reaction,** *Chem. Phys. Lett.* **40,** No. 2, 251-256 (June 1, 1976).

Key words: chemical reactions; classical scattering matrix theory; collision theory; hydrogen atoms; hydrogen molecules; scattering theory; trajectories; uniform approximation.

The Bessel uniform approximation developed by Stine and Marcus is applied to the collinear $H + H_2$ reaction on Diestler's potential energy surface no. 3 to which we have previously applied other orders of approximation of classical *S* matrix theory. It appears that an accurate treatment of this system by classical *S* matrix theory requires interference of real and complex trajectories. Calculations were also performed on two other potential energy surfaces in order to more clearly understand the interrelationships of previous semiclassical and quasiclassical studies of this reaction.

16055. Kuriyama, M., Boettinger, W. J., **On the angular divergence of out-going beams in an asymmetric diffraction geometry,** *Acta Cryst. A* **32,** Part 3, 511-512 (May 1976).

Key words: angular divergence; asymmetric diffraction; diffraction topography; dynamical diffraction; rocking curve.

The well-known relation for the angular divergence of beams diffracted from a perfect crystal in an asymmetric diffraction condition is derived straightforwardly from first principles.

16056. Geller, S. B., **Erasing myths about magnetic media,** *Datamation,* pp. 65-68, 70 (Mar. 1976).

Key words: data loss, magnetic media; devices, effects on magnetic media; fields, effects on magnetic media; magnetic fields, erasure of data; magnetic media, data erasure; magnetic media, data protection.

Magnetic media such as tapes and disks are used to store information for use in ADP systems. These stored data can be obliterated under certain conditions by fields which are produced by various devices. This paper describes the effects on data of devices which include airport metal detectors, x-ray units, radar systems, gamma rays, laser beams, television receivers, and automobiles. It describes the erasing effects of permanent magnets as well as the effects of varying magnetic fields, r. f. fields, light, heat, cold, and time on the stored data. The paper then presents some guidelines for safeguarding the data which are recorded on computer magnetic media.

16057. Morton, M., Fetters, L. J., **Homogeneous anionic polymerization of unsaturated monomers,** Chapter in *Macromolecular Reviews,* A. Peterlin, M. Goodman, S. Okamura, B. H. Zimm, and H. F. Mark, Eds., **2,** 71-113 (John Wiley & Sons, Inc., New York, NY, 1967).

Key words: block copolymers; homogeneous anionic polymerization; monodisperse polymers; unsaturated monomers.

This review discusses the polymerization of unsaturated monomers by carbanionic mechanisms. Particular emphasis is placed on the synthesis possibilities of these systems, i.e., monodisperse polymers, block copolymers, and polymers reactive end-groups.

16058. Saunders, R. D., Ott, W. R., **Spectral irradiance measurements: Effect of uv-produced fluorescence in integrating spheres,** *Appl. Opt.* **15,** No. 4, 827 (Apr. 1976).

Key words: deuterium, arc lamps; Halon; integrating spheres.

A fluorescence effect was detected when a Halon coated integrating sphere was irradiated by a deuterium lamp. This fluorescence, if not accounted for, causes large errors when comparing the spectral irradiance of tungsten lamps to that of deuterium lamps.

16059. Marshall, H. E., **Efficiency impacts of cost sharing on shoreline management,** *Coastal Zone Manage. J.* **2,** No. 4, 369-382 (1976).

Key words: beach erosion control; Corps of Engineers; cost sharing; efficiency; hurricane protection; shoreline management; shoreline protection.

The nation's shorelines are being eroded by high winds and waves. Nonfederal interests have traditionally received federal help in the form of cost sharing for protective structures. This article describes, compares, and evaluates existing and alternative cost-sharing rules for shoreline protection on the basis of economic efficiency. Both engineering and management techniques are examined for beach erosion, hurricane, and emergency coastal flood protection. The present cost-sharing system appears to bias local interests to choose (1) costly techniques of protection, e.g., engineering rather than management techniques, and under certain conditions (2) protective structures overbuilt in terms of the efficient scale. Conclusions are that these biases could be reduced if all engineering and management techniques for reducing shoreline damages were subject to the same percentage cost-sharing rules.

16060. McCulloh, K. E., Dibeler, V. H., **Enthalpy of formation of methyl and methylene radicals of photoionization studies of methane and ketene,** *J. Chem. Phys.* **64,** No. 11, 4445-4450 (June 1, 1976).

Key words: enthalpy of formation; ketene; methane; methyl; methylene; photoionization; rotational energy.

Photoion yield curves for CH_3^+ and CH_2^+ from methane have been measured near threshold at 295 and 115 °K, and the curves for CH_2^+ from ketene have been obtained at 295 and 130 °K. Although the detection efficiencies for positive and negative ions were nearly equal, a search for the ion-pair process yielding $CH_3^+ + H^-$ gave negative results. The methane data are successfully fitted on the assumption that the full rotational energy is available for formation of CH_3^+, but that only two rotational degrees of freedom contribute to the available energy for the process yielding CH_2^+. Neglecting excess energy at threshold, the values $\Delta Hf_0°(CH_3) = 149.4 \pm 0.5$ kJ/mole (35.70 ± 0.12 kcal/mole) and $\Delta Hf_0°(CH_2) = 392.5 \pm 2.1$ kJ/mole (93.8 ± 0.5 kcal/mole) from methane. Correction of the threshold for CH_2^+ from ketene for rotational energy results in the concordant value $\Delta Hf_0°(CH_2) = 390.8 \pm 1.7$ kJ/mole (93.4 ± 0.4 kcal/mole) on the

assumption that excess energy can be neglected at threshold. The mean of the two determinations is selected as the preferred value $\Delta Hf_0°(CH_2) = 391.6 \pm 1.7$ kJ/mole (93.6 ± 0.4 kcal/mole).

16061. Thomas, G. A., Schafer, D. E., Wudl, F., Horn, P. M., Rimai, D., Cook, J. W., Glocker, D. A., Skove, M. J., Chu, C. W., Groff, R. P., Gillson, J. L., Wheland, R. C., Melby, L. R., Salamon, M. B., Craven, R. A., De Pasquali, G., Bloch, A. N., Cowan, D. O., Walatka, V. V., Pyle, R. E., Gemmer, R., Poehler, T. O., Johnson, G. R., Miles, M. G., Wilson, J. D., Ferraris, J. P., Finnegan, T. F., Warmack, R. J., Raaen, V. F., Jerome, D., **Electrical conductivity of tetrathiafulvalenium-tetracyanoquinodimethanide (TTF-TCNQ),** *Phys. Rev. B* **13,** No. 11, 5105-5110 (June 1, 1976).

Key words: electrical conductivity; organic conductors; tetrathiafulvalenium-tetracyanoquinodimethanide; TTF-TCNQ.

New measurements of electrical conductivity along the *b* axis of tetrathiafulvalenium-tetracyanoquinodimethanide (TTF-TCNQ) are combined with published results to provide a comprehensive summary including approximately 600 samples studied at 18 different laboratories. The magnitudes of these measured conductivities do not necessitate the assumption of superconducting fluctuations or any other collective state in which the conductivity exceeds the limitations of single-particle scattering. Since an adequate theory of the limitations of single-particle scattering for TTF-TCNQ does not exist at present, experiment alone does not rule out the possibility that collective effects may somewhat enhance or suppress the conductivity.

16062. Hughes, C. E., Walker, J. C., **POPSS, a system for modelling and analyzing operating system resource allocation strategies,** *Proc. 3rd Texas Conf. on Computing Systems, Austin, TX, Nov. 7-8, 1974, Paper 74-CHO895-3C,* pp. 3-6-1—3-6-8 (IEEE Computer Society Publ. Office, Long Beach, CA, 1974).

Key words: FORTRAN IV; operating system; overhead; resource allocation; simulator; strategies; workload.

This paper describes the parametric operating system simulator POPSS, a FORTRAN IV program which was designed to provide a tool for evaluating operating system resource allocation strategies and to serve as a pedagogical device, providing understanding of the functions, components, and component interactions of operating systems. In order to meet both these objectives the system was designed in such a way as to be both flexible and easy to use. The paper covers the range of resource allocation strategies which may be modelled; the facilities provided for describing workloads; the methods used to simulate operating system overhead; and the tools incorporated for allowing users to extend the range of models beyond those currently built into the system.

16063. Pyke, T. N., Jr., **Network access techniques: Some recent developments,** *Proc. 3rd Texas Conf. on Computing Systems, Austin, TX, Nov. 7-8, 1974, Paper 74-CHO895-3C,* pp. 2-2-1—2-2-4 (IEEE Computer Society Publ. Office, Long Beach, CA, 1974).

Key words: communication; computer networks; network access techniques.

Over the last few years a clear need to help computer network users more efficiently and effectively access network based resources has been recognized. This need has followed the demonstrated feasibility of large scale computer networks that provide a wide variety of resources. It has also resulted from the current availability of a large number of commercial, academic, and Government networks that provide a wide variety of programs, data, and systems resources for users. The functions performed by network access processes and devices that have been implemented or are planned range from basic communications support to applications-oriented capabilities. These functions can be performed within a network environment by techniques ranging from user support processes in host computers to minicomputer-based network access devices, as well as by intelligent terminals. Examples of these functions and of network architectures that support them are given in this paper.

16064. Evans, A. G., Russell, L. R., Richerson, D. W., **Slow crack growth in ceramic materials at elevated temperatures,** *Metall. Trans.* **6A,** 707-716 (Apr. 1975).

Key words: acoustic emission; crack propagation; cyclic conditions; failure times; high temperatures; silicon nitride; slow crack growth.

Techniques for studying slow crack growth at high temperatures are described. The techniques are used to obtain crack growth data for a range of silicon nitrides between 1100 and 1400 °C. For these materials the data suggest that the slow crack growth may be effectively characterized by the relation between crack velocity and stress intensity factor. Data obtained for mechanical and thermal fatigue modes indicate that these behaviors can be predicted with moderate accuracy from the isothermal, static stress parameters (for the range of conditions investigated). Finally, the application of slow crack growth data to failure prediction is described and illustrated using data for one of the materials tested.

16065. Pella, P. A., Kuehner, E. C., Cassatt, W. A., **Development of thin calibration standards for x-ray fluorescence analysis,** *Environmental Protection Technology Series, EPA-600/2-76-126,* 11 pages (Available as PB253252 from the National Technical Information Service, Springfield, VA 22161, May 1976).

Key words: calibration; filters; orchard leaves; standard reference sample; x-ray analysis.

Particulate reference samples have been prepared for the Environmental Protection Agency for use in the standardization of x-ray fluorescence spectrometers. Uniform layers of reground orchard leaves of known composition, i.e., NBS Standard Reference Material 1571, were deposited on membrane filters and coated with a thin polymer film. Samples have been prepared with deposit thicknesses ranging from 0.1 to 5.0 mg/cm^2.

16066. Washer, F. E., **Cameras, optics, and filters for color aerial photography. Lens design for color,** Chapter III in *Manual of Color Aerial Photography, First Edition,* J. T. Smith, Jr., Ed., 94-138 (American Society of Photogrammetry, Falls Church, VA, 1968).

Key words: lens aberrations; lens characteristics; lens distortion; lens resolving power.

This article presents a brief description of lens characteristics and aberrations that are of interest in photography. The various aberrations such as longitudinal spherical, longitudinal chromatic, and lateral chromatic are described together with brief discussions of their effect on imagery and some methods of measurement. Lens distortion, field curvature, and resolving power are also discussed briefly. Figures and tables illustrating various phases of lens performance are included.

16067. Garvin, D., Domalski, E. S., Hampson, R. F., Wagman, D. D., **Chemistry in the stratosphere,** Chapter 5 in *The Natural Stratosphere of 1974, CIAP Monograph 1,* A. J. Grobecker,

Ed., Report No. DOT-TST-75-51, 28 pages (Dept. of Transportation, Washington, DC, Sept. 1975).

Key words: atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant.

This chapter has two objectives. They are (1) to illustrate the problems to be solved in unraveling the chemistry of the stratosphere and (2) to provide the quantitative data needed when chemical reactions are introduced into numerical modeling of the stratosphere. The topics discussed in this chapter, their pertinence to the stratosphere and some principal conclusions are described.

16068. Florin, R. E., **Leo Aloysius Wall,** Biographical item for book *American Chemists and Chemical Engineers,* W. D. Miles, Ed., pp. 490-491 (American Chemical Society, Washington, DC, 1976).

Key words: biography; Wall, L. A.

Short biography of Leo A. Wall.

16069. Evans, A. G., Wiederhorn, S. M., Linzer, M., Fuller, E. R., Jr., **Proof testing of porcelain insulators and application of acoustic emission,** *Am. Ceram. Soc. Bull.* **54,** No. 6, 576-581 (June 1975).

Key words: acoustic emission; macrocracking; porcelain insulators; proof testing; residual strain.

An investigation of proof testing has been conducted on large cone and post porcelain insulators. The cone configuration was unsuitable for overload proof testing to the loads needed for effective lifetime predictions. The only merit of subjecting this configuration to a proof test is the assurance of no immediate macrocracking during installation. This is achieved by testing to a load marginally larger than the service load. Conversely, the post configuration exhibited the basic prerequisites for effective proof testing but detailed stress analysis of this system is needed before specific proof testing procedures can be recommended. Finally, acoustic emission measurements were a major asset for monitoring both macrocracking events and stress development during the proof tests.

16070. Weikel, M. K., Miller, T. R., **A summary of a cost analysis of blood banking alternatives,** *Proc. 3rd Annual Conf. of the Society of Government Economists, Washington, DC, Mar. 23, 1973,* W. E. Kost, Ed., pp. 31-37 (1975).

Key words: blood banking; cost analysis; economics; indirect costs; subsidized costs.

A brief synopsis of parts of NBS Report 10 924, "Cost Analysis of Blood Banking Alternatives," was presented at the Third Annual Meeting of the Society of Government Economists. The presentation included discussion of: current problems related to blood banking; the economic aspects of blood supply and demand; the cost analysis methodology; and the actual results of the cost analysis.

16071. Huffman, J. C., Roth, R. S., Siedle, A. R., **Synthesis of ternary metal sulfide arrays,** *J. Am. Chem. Soc.* **98,** No. 14, 4340-4341 (July 7, 1976).

Key words: clusters; metal-metal bonding; metal sulfides; sulfides; tungsten; x-ray crystallography.

Deoxygenation of $(Ph_3PCH)_2WO_2S_2$ with Ph_2PCH_3 in the presence of a group Ib metal slat led to $[(Ph_2PCH_3)_2Cu]_2WS_4$, $[Ph_2PCH_3)_2Ag]_2WS_4$, $[(Ph_2PCH_3)Ag]_2WS_4$ and $[Ph_2PCH_3)Au]_2WS_4$. Infrared, Raman, electronic, ^1H and ^{31}P nmr spectral data are reported.

The gold-tungsten-sulfur array was characterized by single crystal x-ray diffraction techniques.

16072. Culver, C., **Fire loads and live loads in buildings,** *Proc. Int. Conf. on Performance of Building Structures, Glasgow, Scotland, Mar. 31-Apr. 1, 1976,* **1,** 111-119 (Pentech Press Ltd., London, England, 1976).

Key words: buildings; fire loads; load surveys; occupancy live loads; structural engineering.

The development of a nation-wide survey program for determining fire loads and live loads in buildings and establishing the factors which affect these loads is described. Considerations involved in planning the program and the type of data collected are included. Preliminary survey results obtained from the NBS Administration building are described.

16073. Manning, J. R., **Comparison of matrix inversion, Monte Carlo, and diffusion of probability techniques for calculation of diffusion correlation factors,** (Proc. Symp. on Computer Simulation for Materials Applications, Gaithersburg, MD, Apr. 19-21, 1976), *Nucl. Metall.* **20,** Pt. 1, 109-120 (Apr. 1976).

Key words: computer simulation; correlation factor for diffusion; diffusion; matrix calculation; Monte Carlo calculation; theory of diffusion; vacancy diffusion.

The diffusion correlation factor can be determined by calculating the mean square atom displacement resulting from a long series of atom jumps. Monte Carlo computer simulation techniques are coming more-and-more to be applied to this problem. Possible problems encountered in applying the common matrix inversion technique to correlation factor calculations are discussed, and the relative advantages and disadvantages of matrix inversion and Monte Carlo techniques are examined. In some cases, a diffusion of probability technique that involves only one matrix inversion is found to provide more nearly accurate results than do either the usual matrix inversion or Monte Carlo techniques. As examples, correlation approximations for diffusion in random binary alloys and for diffusion via divacancies are discussed.

16074. Farmer, B. L., Eby, R. K., **Calculations of internal friction resulting from molecular defects in hydrocarbon crystals,** (Proc. Symp. on Computer Simulation of Materials Applications, Gaithersburg, MD, Apr. 19-21, 1976), *Nucl. Metall.* **20,** Pt. 1, 154-165 (Apr. 1976).

Key words: calculations; hydrocarbon crystals; internal friction; molecular defects; pair potentials; site model.

Relaxations observed by dynamic-mechanical measurements of linear hydrocarbon crystals have been attributed to a variety of molecular features. In the present review, molecular defects resulting from the inclusion of isolated methyl-branched molecules and vacancies in the crystals are examined with regard to their possible roles in these relaxations. An approach combining the treatments of a standard linear solid, a site model, and molecular building with computer based semi-empirical potential energy calculations has been used. The results indicate that such molecular defects can indeed play a role in the observed relaxations. The relaxation strength and relaxation times determined from the computational model are in qualitative and semi-quantitative agreement with experimental data.

16075. Davis, R. M., **Federal interest in computer utilization by state and local governments,** *The Bureaucrat* **1,** No. 4, 349-356 (Winter 1972).

Key words: automation; computer utilization; dedicated computers; EDP expenditure; employment; finance; productivity; services—state/local government.

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The size of state and local government labor forces, their expenditures on EDP, and nationwide desires for more government services of better quality provided with increased productivity are national concerns. The federal investment in state and local government EDP is significant. As a result, there is a legitimate interest in the effect federal policies may have on computer utilization by state and local governments. A review of federal policies shows that there is no single overall federal policy imposing any constraints on computer utilization by state and local governments. The Department of Justice in its National Crime Information Center (NCIC) has formulated security and confidentiality provisions applicable only for that system. No other federal agency appears to have policies specific to the dedicated use of computer systems.

16076. Henderson, M., Geddes, S., **Automation and the federal library community: Report on a survey,** *Federal Library Committee*, pp. 1-49 (Library of Congress, Washington, DC, June 1973).

Key words: federal libraries; library automation; survey report.

From June 1970 to July 1971 an intensive investigation was undertaken of the federal library community and its involvement with library automation. The project, initiated by Federal Library Committee's Task Force on Automation of Library Operations, was supported by the U.S. Office of Education and conducted by the System Development Corporation. This report summarizes and abstracts the results of that investigation and highlights the resulting picture drawn of the federal library community. Tables and graphs from the original report and handbook are reproduced in this summary and are referred to the original documents.

16077. McKinney, J. E., Simha, R., **Configurational thermodynamic properties of polymer liquids and glasses. Poly(vinyl acetate). II,** *Macromolecules* **9,** No. 3, 430-441 (May-June 1976).

Key words: compressibility; configuration; entropy; heat capacity; holes; polymer; poly(vinyl acetate); pressure; thermal; volume.

The theoretical internal energy, entropy, and internal pressure of the equilibrium system of poly(vinyl acetate) using the scaling parameters established previously are computed as functions of temperature and pressure and found to be in good agreement with those derived from the experimental PVT data given in paper I. For the analysis of the glassy state, a new method is developed and applied to the two constant formation glasses discussed earlier. It employs the partition function which has the same mathematical form as for the equilibrium system, but derives the hole fraction $h(V, T)$ as the solution of a partial differential equation. This equation results from the proper thermodynamic definition of the pressure in terms of the partition function, applied to the experimental PVT surfaces for the glasses. A quantitative improvement in the compressional thermodynamic functions, particularly in regard to the internal pressure, ensues over the more empirical procedure employed previously. There h is treated as an adjustable parameter in the pressure equation derived for the liquid, using the experimental PVT surface for the glass. The application of the proper expression for the pressure results in a reduced variation of h with temperature and pressure in the glassy state and thus in numerically larger freezing fractions than those derived earlier. We exhibit the internal energy and entropy differences between the atmospheric pressure and pressurized (800 bar) glasses, and between these and the super-cooled melt. The computed difference between the configurational heat capacities of the melt and glass at T_g are about 47 percent for C_p and 13 percent for C_v of the totals obtained by calorimetry. Finally, convenient interpolation expressions for the hole fraction, theoretical internal energy, and theoretical entropy as functions of the reduced variables of state are developed for the equilibrium liquid in general and the two specific glasses considered here. These relations dispense with the necessity of iteration procedures for the numerical evaluation of the theoretical functions.

16078. Stein, R. J., **Angle- and energy-resolved charged particle spectroscopies—A simple way,** *Rev. Sci. Instrum.* **47,** No. 6, 716-719 (June 1976).

Key words: angle and energy distributions; charged particle spectroscopy; electron-stimulated desorption of ions (ESDIAD); field-ion microscopy (FIM); low energy electron diffraction (LEED); ultraviolet photoelectron spectroscopy (UPS).

The acquisition of angular and energy distribution information is of growing importance in a number of charged particle spectroscopies used for surface studies. A simple, inexpensive method is outlined for obtaining a visual display of angular distributions containing energy distribution information in the form of color. In essence, a detector optical bandpass is varied synchronously with an energy-selecting element of a spectrometer having a visual display in order to convert the analyzed particle energy distribution to a corresponding chromatic map. The primary utility of the method would be to obtain qualitative information rapidly in those cases where the particle energy spectra have distinct and strong features or when features of interest lie at the higher-energy end. Examples of the latter are plasma loss structure in low-energy electron diffraction, electron-stimulated desorption ion angular distributions, and the higher-energy structure in ultraviolet photoelectron spectroscopy. Other applications are also considered. The practical sensitivity limit for the case of visual observation is 1.0 percent $[I(\Delta E)/I_{total}]$. This sensitivity is not sufficient for application of the method to Auger electron spectroscopy or electron spectroscopy for chemical analysis.

16079. Penn, D. R., **Quantitative chemical analysis by ESCA,** *J. Electron Spectrosc. Relat. Phenom.* **9,** 29-40 (1976).

Key words: electron spectroscopy for chemical analysis; mean free path; quantitative analysis.

Electron spectroscopy for chemical analysis (ESCA) can be used as a quantitative tool for the determination of the chemical composition of the surface region of a solid if certain parameters are known. The least well known is the electron mean free path. We present values of the electron mean free path for inelastic scattering as a function of energy for all elemental solids (with the exception of the rare earths and the actinides) and we give formulae for the calculation of the mean free paths for compounds. It is shown that this information makes it possible to deduce from ESCA measurements the relative concentration of atoms or molecules distributed homogeneously in the surface region of a material.

16080. Watson, R. E., Herbst, J. F., Wilkins, J. W., **Core level shifts of rare-gas atoms implanted in the noble metals,** *Phys. Rev. B* **14,** No. 1, 18-25 (July 1, 1976).

Key words: core level; implant; noble metals; rare gas; shift.

By means of soft-x-ray photoemission Citrin and Hamann have observed core level shifts of Ne, Ar, Kr, and Xe atoms implanted in the noble metals and have constructed a theoretical model with which to interpret the results. We describe calculations employing a quite different approach to the same physical effects which are as successful numerically. The two salient elements are the energy associated with the screening of the core

hole by the host-metal electrons and the potential shif. arising from the surface dipole of the metal, neither of which is present in the free-atom case. Also considered is the chemical shift due to implantation in the host; estimates of this depend upon details of the model describing the implant site, but for the case at hand we find this contribution to be small.

16081. Hocken, R., Moldover, M. R., **Ising critical exponents in real fluids: An experiment,** *Phys. Rev. Lett.* **37,** No. 1, 29-32 (July 5, 1976).

Key words: CO_2; critical exponents; critical point; equation of state; SF_6; Xe.

We report precise optical measurements of the equations of state of Xe, SF_6, and CO_2 very near their critical points ($|T-T_c|/T_c < 5\times 10^{-5}$). We find that the critical exponents of these fluids in this region are close to the exponents calculated from the three-dimensional Ising model.

16082. Marinenko, G., Huggett, R. J., Friend, D. G., **An instrument with internal calibration for monitoring chlorine residuals in natural waters,** *J. Fish. Res. Board Can.* **33,** No. 4, Part 1, 822-826 (1976).

Key words: amperometry; chlorine monitoring; chlorine residuals; coulometry; flux-monitor; water analysis; water pollution.

To increase the sensitivity of field instruments for measurement of low level chlorine concentrations in natural waters a new monitor was developed. Iodine, resulting from oxidation of potassium iodide by chlorine residual, is measured amperometrically in a system in which coulometrically generated iodine is used as a system calibrant. Laboratory tests, field tests, and comparisons of the new chlorine monitor with other instruments were performed. Data obtained with the new instrument show that chlorine concentrations down to a few parts per billion can be measured. The instrument is portable, and has built-in electrical calibration features and direct read-out display in either microamperes or parts per million of residual chlorine.

16083. Snell, J. E., **Comments on drainage system performance,** *Proc. CIB Commission W62 Symp. on Drainage Services in Buildings, National Swedish Institute for Building Research, Stockholm, Sweden, Sept. 24-25, 1973,* pp. 1:1-1:11 (Swedish Council for Building Research, Stockholm, Sweden, 1974).

Key words: gravity drainage evaluation; plumbing research.

A number of changes are taking place in plumbing system technology that may lead to significant departures from traditional dependence on gravity drainage. These factors include new designs and materials and the need to conserve water. A major concern in facilitating introduction of new technology is overcoming traditional roadblocks to innovation in this field. This paper describes an approach being pursued by the National Bureau of Standards and others to assure that performance of new systems is demonstrated in terms meaningful to local enforcement authorities.

16084. Siu, M. C. I., **Analysis of edge-heat-loss of a guarded-hot-plate apparatus,** *Proc. 14th Int. Conf. on Thermal Conductivity, Storrs, CT, June 2-4, 1975,* P. G. Klemans and T. K. Chu, Eds., pp. 413-422 (Plenum Press, NY, 1976).

Key words: ambient temperature index; edge-heat-loss; errors; guarded-hot-plate apparatus; line-heat-source; thermal conductivity.

Analysis on the error in measured specimen thermal conductivity arising from edge-heat-loss at the periphery of any guarded-hot-plate apparatus is presented. It is shown that the error due to edge-heat-loss varies linearly with respect to the deviation of the ambient temperature from mean specimen temperature. Explicit expressions are presented for the line-heat-source guarded-hot-plate apparatus being constructed at the National Bureau of Standards.

16085. Yates, J. T., Jr., Madey, T. E., Erickson, N. E., Worley, S. D., **Adsorption and condensation of small molecules on tungsten (100) as studied using x-ray photoelectron spectroscopy,** *Chem. Phys. Lett.* **39,** No. 1, 113-117 (Apr. 1, 1976).

Key words: carbon dioxide; carbon monoxide; chemisorption; formaldehyde; oxygen; physisorption; surface chemistry; tungsten; x-ray photoelectron spectroscopy.

X-ray photoelectron spectroscopy (XPS) has been used to examine the adsorption of H_2CO, O_2, CO and CO_2 on the W(100) surface at 100 K and 300 K. Correlations between XPS measurements and kinetic measurements have been made.

16086. Winder, D. R., **Orientation of hexagonal crystals,** *Am. J. Phys.* **38,** No. 3, 319-326 (Mar. 1970).

Key words: crystallography, elementary; crystals, hexagonal; hexagonal crystals; hexagonal lattices.

Interplanar angles and stereographic projections are described for hexagonal structures. Graphs of the variations of some interplanar angles with c/a are given. The four systems of indexing hexagonal lattices are compared.

16087. Culver, C. G., **Comprehensive survey program for fire and live loads in buildings,** *Proc. Public Buildings Service International Conf. on Firesafety in High-Rise Buildings, Seattle, WA, Nov. 18, 1974,* pp. 1-30 (1974).

Key words: buildings; fires; loads; safety; surveys.

The development of a nation-wide survey program for determining fire loads and live loads in buildings and establishing the factors which affect these loads is described. Considerations involved in planning the program, the type of data collected and data processing procedures as well as a brief description of the data analysis are included.

16088. Oser, H. J., **An average distance,** Problem 75-12 in *Problems and Solutions* **18,** No. 3, 497-501 (July 1976).

Key words: average distance; distance; multiple integrals; transportation problem.

Take two unit squares and place them side by side so they form a rectangle two units wide and one unit high. Now choose a point A at random in the first square and, again at random, a point B in the second square. Then A and B will be a certain distance apart. Question: If we repeat the random choice of A and B many times, how far apart will they be on the average?

16089. Fechter, J. V., Jr., **Product safety and product performance research at the National Bureau of Standards,** *Proc. 6th Congress of the International Ergonomics Association "Old World, New World, One World," University of Maryland, College Park, MD, July 11-16, 1976,* pp. 136-140 (The Human Factors Society, Inc., Santa Monica, CA, July 1976).

Key words: human factors ergonomics; product performance; product safety; standards.

In 1974, the National Bureau of Standards established a Center for Consumer Product Technology to conduct product safety and product performance research. The Center's Human Factors Section operates a laboratory which is used for consumer product studies. While much of the Laboratory's equipment and instrumentation is fairly typical of other human factors laboratories, its configuration and application at NBS is unique.

A study of cooking ranges is presented to illustrate how the facility is being used.

16090. Unassigned.

16091. Margulis, S. T., **The ICET testing program for the certification of engineering technicians,** *Prof. Eng.*, pp. 30-31 (Mar. 1976).

Key words: criteria; decision making; human systems; measuring instruments; research assistants; test device evaluation.

The Institute for the Certification of Engineering Technicians (ICET) certifies engineering technicians nationally. New criteria for voluntary certification have been instituted recently. Central to the approach is a new testing program to determine the technical competence of candidates. Those applying for Associate Engineering Technician or Engineering Technician status are required to pass a written examination; those applying for Senior Engineering Technician status must prepare a 5000-word technical essay.

The testing program is described and evaluated and special uses for the written examinations, which ICET proposes, are reviewed. Overall, the testing program suggests careful test development and a desire for continuing development. Tests appear to be technically sound. Plans for test evaluation, by ICET, will more clearly establish the strengths and weaknesses of the tests. Special uses for the tests—for assessing technical obsolescence as part of a continuing professional development program, and for helping candidates prepare for the written examination by completing a short version of the test, are commendable additions to the testing program.

16092. Burch, D. M., Peavy, B. A., Powell, F. J., **Experimental validation of the NBS load and indoor temperature prediction model,** *ASHRAE Trans.* **80,** Part 2, 291-310 (1974).

Key words: dynamic model; environmental chamber experiment; heating and cooling load computer program; heating load; masonry building.

Measurements of the dynamic heat transfer in an experimental masonry building were made in a large environmental chamber to explore the validity of a computer program developed at NBS for computing heating and cooling loads, and indoor air temperatures. The experimental structure was a one-room house 20 ft long, 20 ft wide, and 10 ft high with walls of solid concrete blocks and a flat roof made of reinforced precasts concrete slabs. The building was exposed to a diurnal temperature cycle for a series of tests where changes were made in fenestration, the amount and location of insulation, and the amount of indoor mass. The NBS computer program predicted both indoor air temperatures and heating loads that were in close agreement with the experimental data.

16093. Bordé, C. J., Hall, J. L., Kunasz, C. V., Hummer, D. G., **Saturated absorption line shape: Calculation of the transit-time broadening by a perturbation approach,** *Phys. Rev. A* **14,** No. 1, 236-263 (July 1976).

Key words: lasers; nonlinear spectroscopy; saturated absorption.

We present a third-order perturbation calculation of line shapes in laser spectroscopy based on the density-matrix formalism. The new feature of this theory is the inclusion of the Gaussian spatial structure of the laser beams. We study the linewidth as a function of relaxation and transit times. A shift is found when the wave fronts are not flat. General line-shape formulas are given as well as approximate formulas valid in various domains.

16094. Cheron, B., Scheps, R., Gallagher, A., **Continuum radiation and potentials of Tl-noble gas molecules,** *J. Chem. Phys.* **65,** No. 1, 326-335 (July 1, 1976).

Key words: molecules; radiation; thalium.

Continuum emission intensities on the extreme wings of the Tl resonance lines due to noble gas perturbers have been measured as a function of gas temperature. These spectra, due to the $B^2\Sigma_{1/2} - X\ 1/2$; $B^2\Sigma_{1/2} - X\ 3/2$, and $B^2\Sigma_{1/2} - A\ 1/2$ bands, are interpreted with the classical Franck-Condon principle to yield estimates of the $B^2\Sigma_{1/2}$, $A\ 1/2$, $X\ 3/2$, and $X\ 1/2$ potentials of Tl-noble gas molecules. As has been noted qualitatively in matrix isolation studies, the Group III elements form unusually stable diatomic bonds with the "inert" gases, e.g., we find Tl-Xe bound by ~300 cm^{-1}. The Tl-Xe system is an interesting visible, excimer laser candidate, as the molecular spectra extend very far into the red wings of the resonance lines.

16095. Niatel, M. T., Loftus, T. P., Oetzmann, W., **Comparison of exposure standards for ^{60}Co gamma rays,** *Metrologia* **11,** 17-23 (1975).

Key words: cobalt-60; exposure standard; international intercomparison.

Comparisons for ^{60}Co gamma rays between the exposure standards of the Bureau International des Poids et Mesures (BIPM), the National Bureau of Standards (NBS) and the Physikalisch-Technische Bundesanstalt (PTB) are reported. For measurements made at about one meter from the source, and if the same physical constants are used, the differences are 0.26 percent between the BIPM and NBS standards, and at most 0.4 percent between the BIPM standard and the PTB standard chambers. The differences are consistent with the estimated systematic uncertainties (≈0.5%).

The difference between the NBS standard and the PTB chamber measurements, as determined through the ratios of each to the BIPM chamber, ranges from 0.17 to 0.66 percent. The difference in exposure standards for NBS and PTB actually ranges from 0.48 to 0.97 percent, since different stopping power corrections are used by these two laboratories.

An indirect comparison of the BIPM and NBS standards indicates that the difference of 0.26 percent will increase to 0.55 percent at a distance of two meters.

16096. Guildner, L. A., Johnson, D. P., Jones, F. E., **Vapor pressure of water at its triple point: Highly accurate value,** *Science* **191,** 1261 (Mar. 26, 1976).

Key words: precision mercury manometer; triple point of water; vapor pressure of water.

The vapor pressure of water at its triple point was measured with greatly increased accuracy. The triple point was realized with newly designed equipment that enhanced the stability of the pressure and permitted any air released from solution to be removed by pumping. A diaphragm pressure transducer separated the water vapor from the helium used to transmit the pressure to the manometer. The pressure was measured with the National Bureau of Standards precision mercury manometer. The vapor pressure at the triple point was found to be 611.657 pascals with random uncertainties at the 99 percent confidence level of ±0.010 pascal. The systematic errors are estimated to be relatively insignificant.

16097. Spencer, L. V., Eisenhauer, C., **Reflection of charged-particle beams at near-grazing incidence,** *Trans. Am. Nucl. Soc.* **23,** 609-610 (June 1976).

Key words: Albedo; angular distribution; backscatter; charged particles; Monte Carlo; reflection.

An analytic expression is given for the angular distribution of charged particles reflected from a surface for a near-grazing incident beam. This expression predicts the apparent specular reflection peak observed in experiments and Monte Carlo calculations.

16098. Novick, R., Sprott, G., Lucatorto, T., **Identification of the lowest metastable autoionizing level in Rb from rf spectroscopic studies,** *Phys. Rev. A* **14,** No. 1, 273-278 (July 1976).

Key words: atomic beam; autoionization; differential metastability; fine structure; inner shell excitation; rf spectroscopy; rubidium; Zeeman effect.

The lowest Rb metastable autoionizing level has been identified by a rf resonance measurement of the g factors of the various hyperfine sublevels. Of the two lowest-lying metastable state assignments, $4p^5(^2P)5s5p(^3P)^4D_{7/2}$ and $4p^54d(^3F)5s^4F_{9/2}$, only components of the $^4D_{7/2}$ were observed in the metastable beam. The atomic-beam resonance method employed resembles traditional methods except that it exploits the differential metastability of the fine-structure levels instead of magnetic deflection for state selection.

16099. Jeffery, S., Branstad, D. K., **Security considerations in software systems,** *Proc. 3d Texas Conf. on Computing Systems, Austin, TX, Nov. 7-8, 1974, Paper 74-CHO895-3C,* pp. 8-4-1 – 8-4-4 (IEEE Computer Society Publ. Office, Long Beach, CA, 1974).

Key words: security, software; software engineering; software systems.

Software engineering may well be the foundation upon which security of computer systems will be built for the near future. Self-protecting systems, those which have the internal mechanisms to prevent technical assaults on the computer system's integrity are needed to prevent the unauthorized modification or disclosure of information stored and processed within the system. While most time-shared or multi-programmed computer systems do incorporate rudimentary protection mechanisms which prevent accidental damage to the operating system and to other concurrently processing programs, no general system has withstood the technical onslaught of penetration teams authorized to test its security features. The generic flaws found and analyzed by these penetration teams can be traced to poor design criteria and/or poor programming techniques. This paper discusses some of the fundamentals of software engineering needed to be used and extended in building secure computer systems.

16100. Armstrong, G. T., **Reaction calorimetry of fluorine and the thermochemistry of its compounds,** *L'Actualité Chimique,* pp. 5-14 (Feb. 1976).

Key words: bomb calorimetry with fluorine; enthalpy of formation, fluorides; flame calorimetry of fluorine and fluorides; procedures, experimental for handling fluorine.

The importance, the advantages, and the difficulties of using elemental fluorine for reaction calorimetry are discussed. Techniques developed at NBS for bomb calorimetry and gas flame calorimetry with elemental fluorine or fluorine-containing compounds as oxidizers are discussed together with their application to substances such as CF_4, BF_3, ClF, ClF_3 and refractory compounds such as B_4C. The accuracy achieved and the scope of possible measurements are discussed in relationship to the status of the thermochemistry of fluorine compounds.

16101. Beausoliel, R. W., Phillips, C. W., Snell, J. E., **Field investigation of natural gas pipeline accident, Canterbury Woods, Annandale, VA,** *Fire J.* **68,** No. 3, 77-84 (May 1974).

Key words: Annandale; field test; gas explosion; leak detection.

On the morning of March 24, 1972, in Annandale, Virginia, two homes were destroyed and a third home damaged by gas explosions and fires resulting from a construction accident that caused the gas main leak. The National Transportation Safety Board was responsible for investigating this accident and requested that the National Bureau of Standards assist them with their investigation by conducting a field test at the accident site.

The objective of the test was to determine how the natural gas entered the homes and the paths the gas followed from the leak to the homes. The premise of the NBS test was that if an air-tracer mixture could be detected at locations where natural gas was known to have escaped, then the original underground gas paths may still exist. A detailed test plan was developed to determine gas escape locations and paths. This plan included a simulation of the underground gas movement, excavation of various utility trenches, soil tests, and dismantling of the foundation wall of one of the destroyed homes. The equipment used to introduce the tracer into the ground near the original leak consisted of an air compressor, a tracer source (refrigerant R-12), air flow measuring, piping and control valves. Electronic catalytic leak detectors were used to detect the tracer in homes and elsewhere on the test site. The test results substantiated the basic test premise, and tracer was detected in the basements of the two destroyed homes and the damaged home, but not in the undamaged homes. From the results, it is concluded that gas traveled through rock rubble on the site and used as backfill in utility trenches containing the individual water and sewer lines to the destroyed/damaged homes and entered the homes through leaks in their concrete block foundations.

16102. Blevin, W. R., **Black coatings for thermal radiation detectors,** *Proc. Smithsonian-Eppley Symp. on Solar Radiation. Measurements and Instrumentation, Rockville, MD, Nov. 13-15, 1973,* pp. 18-31 (1973).

Key words: black coatings; detectors; radiometry; reflectances.

One of the most critical components of a thermal radiation detector is the black coating that serves to absorb the incident flux and then to conduct the heat to the underlying receiver. Methods for measuring the optical and thermal characteristics of black coatings are reviewed, and results are given for a few different types of coating. The effect of the thermal characteristics of the coating on the detector responsivity is discussed, for both steady and modulated beams of radiation, and the related correction that is required with electrically calibrated detectors is described.

16103. Buhl, D., Snyder, L. E., Lovas, F. J., Johnson, D. R., **Is there a maser in the silicon monoxide ground state?,** *Astrophys. J.* **201,** No. 1, L29-L31 (Oct. 1, 1975).

Key words: circumstellar shells; masers.

Observations of the ground state ($v=0, J=2-1$) transition of silicon monoxide (SiO) show a rather smooth, low-intensity profile stretching over a large velocity range. The presence of ground-state emission at velocities which are not present in the $v=1$ or $v=2$ lines is interpreted as thermal emission in the ground state in regions where there is insufficient excitation to produce the vibrationally excited masers. Only VY CMa shows a profile which could be interpreted as ground-state maser emission.

16104. Cali, J. P., **Rationale for reference methods in clinical chemistry,** (Proc. Symp. 9th Int. Congress on Clinical Chemistry, Toronto, Canada, July 13-18, 1975), Paper in *Pure and*

Applied Chemistry **45,** 63-68 (Pergamon Press, Ltd., Headington Hill Hall, Oxford, OX3 United Kingdom, 1976).

Key words: definitive method; matrix reference materials; pure reference materials; reference methods; routine methods; secondary reference materials; Standard Reference Materials.

In the field of clinical chemistry evidence is mounting that a reliable and medically relevant structure can be built on the concept of compatibility through accuracy in measurement. By compatibility is meant the ability of all laboratories in a network to achieve on a given sample similar and reliable numerical values for a property under test. It is shown that when all laboratories in a network are making accurate measurements, i.e., free of sytematic error and precise, then compatibility automatically ensues. The need for accurate measurement based on medical arguments is given.

In order to build an accurate measurement network, three measurement methodology levels and three types of reference materials are required. A *definitive method* is directly able to realize or to have access to the base or derived units of the measurement system. It depends in part on the availability of *pure reference materials* (e.g., those supplied by the National Bureau of Standards and called SRM's). At the next level are *reference methods* and *matrix reference materials.* These methods and materials are more adapted to implementation and use by clinical reference laboratories and the manufacturers of *secondary reference materials.* In turn these materials are used at the local level to control the quality and accuracy of the *routine methods.* How this hierarchy of methods and reference materials is structured is discussed.

The role of the definitive method is discussed in some detail, because of its crucial place in the structure. Potentially useful definitive methods, both for inorganic and organic constituents are outlined. A discussion of reference method developments, per se, is left to the other three authors of this Symposium (qv). Clinical SRM's now available are listed, as well as those now in preparation at NBS. The need for matrix reference materials is stated.

Finally, how this measurement network should be structured and implemented together with suggested organizations responsible for the various levels is discussed.

16105. Unassigned.

16106. Horowitz, E., **Standardization of plastics,** *Encycl. Polym. Sci. Technol.* **12,** 771-786 (1970).

Key words: plastics standardization; specifications; standards; standards organization; test methods.

This paper briefly discusses various organizations engaged in promoting, developing and promulgating standards, specifications, test methods and related documents in the field of plastics. In some cases the procedure for preparing standards and specifications, and the mechanism for their adoption is described. Examples are given of the types of standards and specifications that are available as well as the different classes of plastics materials that are covered. Plastics standardization activities at both the national and international levels are treated and references to the literature are provided.

16107. Kashiwagi, T., Newman, D. L., **Flame spread over an inclined thin fuel surface,** *Combust. Flame* **26,** 163-177 (1976).

Key words: flame spread; instability; radiant flux; α-cellulose.

Downward flame spread velocity over a thin α-cellulose sheet was measured from the vertical to the horizontal positions under external radiant fluxes of 0, 0.9, 1.4 and 2.0 W/cm^2. The flame spread velocity had little dependency on the angle of inclination of the sheet with the stable lower flame. When the lower flame became unstable, wavy flames, cellular flames and flame rolls were observed below the lower surface. With these unstable lower flames, the flame spread velocity increased significantly reaching several cm/s. Qualitative analysis based on the Rayleigh instability mechanism describes well the effects of the inclination angle and the external flux on the instability of the lower flame.

16108. McCaffrey, B. J., Heskestad, G., **A robust bidirectional low-velocity probe for flame and fire application,** *Combust. Flame Brief Communications* **26,** 125-127 (1976).

Key words: angular insensitivity; fluidic device; hot wire anemometer; ion deflection device; laser Doppler anemometer; Reynolds number.

A robust bidirectional flow measuring device has been evaluated and appears to have significant advantages over a pitot-static tube for use in fire research studies. Three different diameter probes were used to secure a low Reynolds number calibration needed for accurate assessment at very low velocities. The bidirectional capability is illustrated by an example of the use of the probe in a scale model corridor-burn room facility.

16109. McNesby, J. R., **New techniques for the measurement of air pollutants,** *Proc. Int. Symp. on Recent Advances in the Assessment of the Health Effects of Environmental Pollution, Paris, France, June 1974,* Paper No. 47, 1-15 (1974).

Key words: ambient air; automotive emissions; laser magnetic resonance technique; stack emissions.

Measurement research in air pollution at the National Bureau of Standards includes that applicable to ambient air, stack emissions, and automotive emissions. Some of the measurement techniques developed for source emission application have been refined and made sufficiently sensitive to measure pollutant concentrations as low as background levels. The fluorescence monitor for sulfur dioxide developed by Dr. Okabe and his colleagues has been applied commercially to the problem of stack monitoring. More recently the sensitivity of the technique has been improved very substantially so that ambient air sulfur dioxide concentrations can be measured at least down to 1 part in 10^9. This apparatus will be described and its capabilities delineated. The technique of laser magnetic resonance for the measurement of NO at concentrations typical of stack emission and auto exhaust has similarly been extended to include ambient concentrations. In addition, progress has been made in the direction of simultaneous measurement of NO_2 by the same technique. The most recent data obtained by the laser magnetic resonance technique will be presented. A third measurement technique developed at the National Bureau of Standards, that of dual angle, forward laser scattering for the real time measurement of particle size distribution has now been shown to be capable of revealing morphological and chemical information. The development of pyrolysis as an alternative to permeation tubes and standard gas cylinders will be described. The principle of the pyrolytic technique is that a thermally stable molecule which may be stored indefinitely is subjected to thermal decomposition producing a nonstorable molecular species plus an exactly equal number of storable, readily measured molecular species. The pyrolytic technique has the inherent capability of tying together virtually all gaseous pollutant molecules in a single, self-consistent measurement and calibration scheme.

Finally, an absolute coulometric technique for the determination of parts per million concentrations of NO in nitrogen will be described. The technique has been used to generate confirmato-

ry evidence for establishing the integrity of NO in nitrogen Standard Reference Materials.

16110. Mears, T. W., **NBS Standard reference materials: Their characterization and stability consideration,** *Proc. of the SAMA Calibrator Product Class Standard Forum and Stability Testing Workshop, Chicago, IL, Mar. 18-19, 1975,* 10 pages (Scientific Apparatus Makers Association, Washington, DC 20036, 1975).

Key words: accelerated testing; clinical; hazards; legal problem packaging; shipping; stability; standard reference materials.

The NBS Office of Standard Reference Materials issues some 800 standard reference materials. The mode of operation developed over the past 75 years relating to testing, certification, and elimination of errors is described. With the inclusion of organic and clinical materials in the program, new considerations were necessary. Packaging techniques were changed. Stability, particularly accelerated testing has become a real problem. The handling and shipping of potentially hazardous materials is more apparent. Finally, in the clinical area, the SRM program has come under the purview of the Food & Drug Administration. The facing and solving of these new problems are described.

16111. Robertson, A. F., **Potential heat: Considerations in the application of a new fire test,** *Fire Mater.* **1,** No. 1, 9-13 (Mar. 1976).

Key words: building materials; calorimetry; combustibility; flammability; heat release rate; potential heat; self heating.

A review is presented of the nature of the potential heat test method. It is emphasized that the procedure usually yields a property-type measurement of the material or composite when applied. As a result, care must be taken to insure that necessary supplementary tests are performed by other methods to guarantee that a substantial fraction of the possible fire hazard has been considered. Suggestions for appropriate use of the procedure are included and information available on the precision of the procedure is reviewed. It is concluded that, when properly applied, the procedure can serve well as one of the tools for characterizing possible fire hazards. Suggestions are made for possible future development of the procedure to yield information on rate of heat release.

16112. Rockett, J. A., **Fire induced gas flow in an enclosure,** *Combust. Sci. Technol.* **12,** 165-175 (1976).

Key words: fire; fire plume gas flow; room fires.

The gas flow induced by a small fire in a large room is considered. The fire plume acts as a pump and the window opening as a throttle. Generalizations of Kawagoe's expressions for the window air flow and height of the neutral plane are developed and used to rationalize previously unexplained features of Gross and Robertson's enclosure fire data.

16113. Benjamin, I. A., **Problems in the correlation of small and large scale tests,** *Proc. Int. Symp. on Fire Safety of Combustible Materials, Edinburgh, Scotland, Oct. 15-17, 1975,* **1,** 141-148 (1975).

Key words: fire tests; regulatory tests; simulation tests.

This paper attempts to show that there are problems in defining large scale tests: the validity of the large scale test is no better than the scenario chosen for its conduct. A review of the literature shows that the small scale tests now being used to evaluate wall and ceiling linings do not measure well what they are designed to measure. Future small scale tests should be derived from studies of large scale tests which are designed to determine the properties to be measured. The small scale tests will then show better correlation to large scale tests.

16114. Eisenhart, C., **Samuel Stanley Wilks,** *Dictionary of Scientific Biography* **XIV,** 381-386 (Charles Scribner's Sons, New York, NY, 1976).

Key words: *Annals of Mathematical Statistics;* bibliography; distribution-free methods; educational testing; mathematical statistics; multivariate analysis; order statistics; social sciences, services to; statistical education in the United States; statistical tolerance limits; U.S. Army programs in statistics; U.S. Government, services to; Wilks award; Wilks, S. S.

A review of the life and work of Samuel Stanley Wilks (1906-1964). His impact on the development of mathematical statistics; and on the development of statistical education in the United States. His services to the U.S. Government, and to the social sciences. Bibliography of principal original works; and of major secondary literature.

16115. Eisenhart, C., **William John Youden,** *Dictionary of Scientific Biography* **XIV,** 552-557 (Charles Scribner's Sons, New York, NY, 1976).

Key words: calibration designs; chain blocks; collaborative tests; diagnostic tests, index for rating; experiment design, statistical; graphical diagnosis; interlaboratory tests; randomization, constrained; ruggedness test; statistical techniques; Youden plot; Youden squares; Youden, W. J.

A review of the life and work of William John Youden (1900-1971). His invention of new techniques for statistical design of experiments and for analysis of data from individual experiments and from groups of experiments. Bibliography of principal original works; and of major secondary literature.

16116. French, J. C., **The ARPA/IC/NBS Semiconductor Technology Program,** *Proc. Space System Microelectronics Seminar, Los Angeles, CA, Apr. 15-16, 1975,* pp. 189-199 (The Aerospace Corp., Los Angeles, CA, July 31, 1975).

Key words: automation; integrated circuits; measurements; microelectronics; process control; reliability; semiconductor.

Reliable devices at lower cost, available when needed, are essential to the achievement of Department of Defense (DoD) systems objectives. The ARPA/IC/NBS Program, Advancement of Reliability, Processing, and Automation for Integrated Circuits with the National Bureau of Standards, supported by ARPA and conducted by NBS, reflects an emphasis on in-process measurements to achieve these objectives. Rather than following only the more traditional and costly approach of tested-in reliability, this program provides a new and complementary thrust directed toward the goal of built-in reliability through design control of fabrication, and automation. The concepts and approaches of this program are based on the experience gained in over a decade of activity in the NBS Semiconductor Technology Program and the transfer of the results obtained in this program to the industry with substantial benefit to both the industry and to DoD. Topics selected for attention cover key processing and assembly steps, from control of incoming materials to evaluation of electrical characteristics and packaging. The selection of topics for consideration is based on extensive field surveys, workshops, and direct interaction with industry and other agencies to determine the measurement needs both for manufacturing and marketplace interactions. An important factor in the program is continued close interaction with the industry to ensure transfer of the results of the program to the industry for use by the semiconductor integrated circuit manufac-

turer, his suppliers, and customers. Both in-house studies at NBS and efforts contracted out-of-house to industry, universities, and other government laboratories are being utilized.

16117. Judd, D. B., Nickerson, D., **Relation between Munsell and Swedish Natural Color System scales,** *J. Opt. Soc. Am.* **65,** No. 1, 85-90 (Jan. 1975).

Key words: color; colorimetry.

The degree to which Munsell hue, value, chroma and the Swedish Natural Color System variables of blackness, whiteness, redness, yellowness, greenness, blueness describe the same color space is shown by simple formulas.

16118. Kusuda, T., **NBSLD-National Bureau of Standards heating and cooling load determination program,** *APEC J.* **VIII,** No. 6, 4-11 (Winter 1973-1974).

Key words: computer program for buildings; conduction transfer functions; heating and cooling load; National Bureau of Standards load determination procedure.

A comprehensive treatment of building heat transfer processes has been incorporated into a computer program called NBSLD in order to study the effect of various building parameters upon the resulting heating and cooling load. The basis of the computation in the program is the detailed solution of simultaneous heat balance equations at all of the interior surfaces of a room or space. Transient heat conduction through the exterior walls and in the interior structures is handled by using ASHRAE type conduction transfer functions. The use of heat balance equations, although more time consuming for the calculation, avoids uncertainties inherent in a weighting factor approach. Thus, precision is improved for a specific building design. Described in this paper are some of the salient features of NBSLD and results of sample calculations which demonstrate the capability of this computer program.

16119. Goldman, A. J., **Discussion,** (Proc. Symp. on Systems Analysis for Social Problems, Gaithersburg, MD, May 26-28, 1969), Paper in *Systems Analysis for Social Problems,* A. Blumstein, et al., Eds., pp. 93-103 (Washington Operations Research Council, Washington, DC, 1970).

Key words: operations research; systems analysis; urban problems.

The increasingly "solid" quality of some recent applications of systems-analysis (SA) techniques to urban problems is noted. Particular emphasis is suggested on the city's success in performing those special functions for which it is peculiarly suited. The conflicting goals of and the struggle for scarce resources among urban interests are observed to be antithetical to SA's penchant for "optimizing" formulations; urban problems admitting such "clean" treatment are held unlikely to be among the underlying difficulties of our cities, but may provide suitable starts for analysis. Concern is voiced that city "institutionalization" of SA may inhibit its search for bold solutions.

16120. Powell, F. J., **Research on energy conservation in building at the National Bureau of Standards,** (Proc. Conf. on Buildings and the Environment, Cary Arboretum of New York Botanical Garden, Millbrook, NY, Nov. 1974), Chapter 6 in *Buildings and the Environment,* R. Goodland, Ed., pp. 114-140 (Cary Arboretum, Millbrook, NY, 1976).

Key words: buildings energy; energy conservation; NBS programs.

Selected topics of the National Bureau of Standards energy conservation program related to buildings are discussed. Topics included are the National Bureau of Standards Load Determination Computer Program (NBSLD) for estimating building energy consumption, the experimental results of tests on a masonry and a woodframe house, the status of an experiment on a mobile home, the study to retrofit an existing house on the NBS grounds to save energy, the experiment to retrofit a townhouse with solar collectors and storage systems to supply 75 percent of the annual energy needs of the townhouse, the energy conservation demonstration office building at Manchester, New Hampshire, and a new energy conservation school in New York City. Other energy conservation efforts are named by title only.

16121. McNesby, J. R., **Air pollution monitoring instrumentation,** *Proc. Naval Environmental Protection Data Base Instrumentation Workshop, Port Hueneme, CA, July 11-12, 1972,* pp. 150-155 (Naval Civil Engineering Laboratory, Port Hueneme, CA, 1972).

Key words: carbon monoxide; hydrocarbons; measurement; nitrogen dioxide; particulate matter; photochemical oxidants; standards; sulfur dioxide.

The first fundamental of air pollution abatement in the U.S. is that all U.S. residents are entitled to breathe air of at least standard quality. The standard quality is spelled out in the National Ambient Air Quality Standards. Secondly, the states are responsible for achieving this quality.

The states must answer these questions: How bad is the air quality now? How much do we have to improve it? To answer the first question we must measure the present levels of the pollutants sulfur dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, photochemical oxidants and particulate matter. The second question is answered by studying the quantitative relationship between ambient air pollutant concentrations and the amounts of pollutants emitted by the various source (modeling). This in turn requires measurement of pollutants emitted through smoke stacks and auto exhausts.

Without accurate methods of measurement, auto manufacturers cannot know their progress towards a low emission vehicle and cannot be sure of their progress relative to that of their competitors. Power plants cannot determine the efficiency of scrubbing devices; cities and states cannot determine if they are successfully implementing their ambient air goals.

16122. Riley, M. E., Truhlar, D. G., **Effects of the Pauli principle on electron scattering by open-shell targets,** *J. Chem. Phys.* **65,** No. 2, 792-800 (July 15, 1976).

Key words: electron exchange; electron scattering; hydrogen atoms; indistinguishable particles; phase shifts; quantum mechanics; scattering theory; semiclassical approximation.

The semiclassical exchange approximation and three free-electron-gas exchange approximations are applied to electron scattering from the hydrogen atom. In the triplet spin state the results are similar to our previous findings [M. E. Riley and D. G. Truhlar, J. Chem. Phys. **63,** 2182 (1975)] for electron scattering by closed-shell atoms. However these results, already of useful accuracy, are improved by the inclusion of one-electron exchange terms or an orthogonality constraint. For the singlet spin state it is essential to include the one-electron exchange terms except at high impact energies (greater than about 50 eV). The approximation of Lippmann, Schey, Burke, and Chandra for treating the triplet spin state and exchange with closed-shell targets is tested and found to be less accurate than the present approximations.

16123. Robertson, A. F., **Estimating smoke production during building fires,** *Fire Technol.* **11,** No. 2, 80-94 (May 1975).

Key words: building; estimating; fire; furniture; hazard; interior finish; smoke.

In the absence of specific analytical methods for measuring the hazards of fire gases, there is a trend toward the use of smoke production as a partial measure of this hazard. It is indicated that prediction of smoke concentrations and thus photometric properties during actual fires requires many important and rather critical assumptions.

16124. Robertson, A. F., **Test method categorization and fire hazard standards,** *ASTM Stand. News* **3,** No. 11, 18-20 (Nov. 1975).

Key words: ASTM; classification; fire hazard; participation; property; system; test method.

A general discussion is presented with the objective of distinguishing between different levels of test method complexity. It is suggested useful to understand the possibility of participation between the specimen and test equipment. A further distinction is proposed between property and system type tests as well as the usual classification on the basis of whether the specimen is destroyed or not. It is shown that fire test methods may be of either the property or system type, although often they are of the destructive participative system type the most complex of those discussed. Both the developers and users of tests are cautioned to recognize and observe the different ways in which it is appropriate to use property and system type test methods. Those responsible for development of such test methods are cautioned against the delivery of methods with the aura of system methodology but lacking in technical validity for the intended use.

16125. Robertson, A. F., **Two smoke test methods—A comparison of data,** *Fire Technol.* **10,** No. 4, 282-286 (Nov. 1974).

Key words: fire propagation test; fire tests; smoke density chamber; smoke tests; test comparison; UK; USA.

Smoke test methods have been developed in both UK and USA which are based on photometric measurements of smoke accumulation in closed chambers. The British Fire Research Station (FRS) procedure makes use of a large room approximately 37 times the volume of the box type chamber used in the test developed at the National Bureau of Standards (NBS). Tests have been conducted to compare the ability of the two measurement methods to assess smoke production from samples of selected materials. It is concluded that similar smoke measurements are obtained by use of the NMS procedure and use of the NBS specimen pyrolysis equipment in the room used for the FRS test. Moreover, there is general correspondence of the NBS and FRS smoke characterization results for many materials. However, these two methods tend to yield different results for high fuel content materials when the limited air circulation permitted by the FRS furnace becomes important, and for thermoplastic materials which in the FRS test melt and reticulate from heat exposure and do not burn. The findings suggest that the FRS method may be more sensitive to system effects of fire within an enclosure. Questions are raised as to whether the system simulated by the FRS test is the appropriate one.

16126. Sinha, S., Bardsley, J. N., **Symmetric charge transfer in low-energy ion-atom collisions,** *Phys. Rev. A* **14,** No. 1, 104-113 (July 1976).

Key words: alkali ions; calcium; charge exchange; charge transfer; cross section calculations; ion-atom collisions; rare-gas ions; uranium.

Previous calculations of ion-atom interactions by the pseudopotential and asymptotic methods are used in the computation of the cross section for symmetric charge transfer at energies below 1 keV. The results for Li^+, Na^+, K^+, Rb^+, Cs^+, and Ca^+ ions are compared with data obtained in beam experiments, and by optical-pumping techniques. The difference in the cross sections for $^2P_{1/2}$ and $^2P_{3/2}$ ions of Kr^+ and Xe^+ at thermal energies is studied, and the predictions are compared with recent mobility measurements. Cross sections are obtained for U^+-U collisions, and the dependence of the thermal cross section on the polarizability is described. Symmetric charge transfer of the negative ions H^-, Na^-, and Cs^- is discussed briefly.

16127. Stein, M. L., **A saddlepoint theorem for self-dual linear systems,** *Linear Algebra and Appl.* **9,** 55-65 (1974).

Key words: combinatorial equivalence; linear inequalities; linear programs; pivot operations; skewsymmetry.

Let A be a skew matrix of order n over an ordered field. There is a finite class of skew matrices $\overline{A}$ such that $\overline{X}\overline{A} = \overline{Y}$ and $XA = Y$ have the same solution sets, where $x_i = y_i$ and $y_i = x_i$ for some indices i (perhaps none) and $x_i = x_i$, $y_i = y_i$ for the remaining i. We show that for each index h, $1 \leqq h \leqq n$, there exists and $\overline{A}$ such that $\overline{a}_{hj} \geqq 0$ for all j. There are a variety of applications to matrix games, linear programs and related topics.

16128. Walston, W. H., Federman, C., **Fourier transform techniques for the calibration of shock accelerometers,** (Proc. 21st Int. Instrumentation Symp. on Instrumentation in the Aerospace Industry, Philadelphia, PA, May 19-21, 1975), Paper in Vol. 21 *Instrumentation in the Aerospace Industry* and Vol. 12 *Advances in Test Measurement*, B. Washburn, Ed., pp. 315-321 (Instrument Society of America, Pittsburgh, PA, 1975).

Key words: accelerometer; calibration; FFT; Fourier transform; Fourier transform frequency; mechanical shock; shock generator.

Calibration of mechanical shock accelerometers is accomplished by a shock comparison method which utilizes fast Fourier transform (FFT) techniques. This procedure computes sensitivity values at any frequencies desired over the entire calibration bandwidth. Pitfalls associated with the application of the FFT to actual shock pulses along with possible solutions are discussed. Close agreement with conventional sinusoidal calibration is obtained.

16129. Snell, J. E., Achenbach, P. R., Petersen, S. R., **Energy conservation in new housing design,** *Science* **192,** No. 4246, 1305-1311 (June 25, 1976).

Key words: energy conservation; energy efficient design; life-cycle cost models; new housing.

The combined influences of rising fuel prices and a national goal of energy independence are providing strong impetus to the consideration of energy conservation in design features in housing. This paper examines the potential implications of these influences to new housing design over the balance of this century. A life-cycle cost model is presented and used to estimate the influence of conservation and fuel price increase on a number of major housing design parameters. These parameters include housing type and size, thermal resistance, location, heating and cooling system capacity and efficiency. Next, the technological realities of achieving such changes are examined and the anticipated impacts of energy conservation on new housing design are summarized. It is felt that the principal emphasis will be on smaller more efficient dwellings, mechanical systems, and equipment with essentially improved overall performance utilizing technology readily available to the building industry.

16130. McNesby, J. R., **Problems in the measurement of free radical concentrations in the atmosphere,** *Ber. Bunsenges. Phys. Chem.* **78,** No. 2, 158-162 (1974).

Key words: chemical kinetics; free radicals; measurement; stratosphere.

The free radicals known, or suspected to be present in the earth's stratosphere have been listed by Garvin and Hampson and include O, O_2, SO, H, OH, HO_2, CH, CHO, CH_3, CH_3O, CH_3O_2, NH, NH_2, HNO, NO, NO_2, NO_3. In the urban troposphere near ground level, this list can be greatly expanded to include many species resulting from reactions of these simple radicals with reactive hydrocarbons. Since the economical control of air pollution requires a detailed knowledge of the chemical kinetics involved in removal of stable pollutant molecules from the air, it is desirable ultimately to be able to measure the concentrations and rate constants of all such reactants. I have selected from this list the two most abundant, polar atmospheric free radicals, NO and NO_2 for discussion. The ground states of NO, $^2\pi$ and of NO_2, $^2A_1$, qualify both molecules as free radicals. These molecules pollute the urban atmosphere and the stratosphere and the debates about the amounts in which they are present have precipitated major controversies in the United States and elsewhere. My purpose is to present the nature of the tropospheric problem of NO and NO_2 (known collectively in the trade as NO_x) why their measurement is important, the current state of the art and finally some of the newer approaches to the solution to the problem in terms of the basic Federal legislation in the United States, the Clean Air Act.

16131. Broussalian, V. L., **Risk measurement and safety standards in consumer products,** (Proc. Conf. on Research in Income and Wealth, Washington, DC, Nov. 30-Dec. 1, 1973), Paper in *Household Production and Consumption,* N. E. Terleckyj, Ed., **40,** 491-524 (National Bureau of Economic Research, New York, NY, 1976).

Key words: consumer products; product safety; refrigerator standards; risk measurement; safety standard; unreasonable hazards.

A definition of unreasonableness of a hazard is proposed. Although formally stated in economic terms, it calls for data of different kinds: engineering, political, psychological, legal, etc. Unreasonableness of a hazard is also related to injury avoidance actions which might be taken by consumers as well as by producers. To demonstrate how the definition may be used in practice, it is applied to an actual hazard for which a mandatory safety standard has been set. This example is the well-known refrigerator entrapment hazard. Finally, the risk data needed to determine whether a hazard is reasonable or not are indicated.

16132. Cooper, J. W., **High-energy dependence of the molecular-hydrogen photoionization cross section,** *Phys. Rev. A* **9,** No. 5, 2236-2237 (May 1974).

Key words: hydrogen; molecular cross section; photoeffect.

The photoionization cross section for H_2 per atom has recently been reported to be ~45 percent larger than the atomic cross section at energies of 5.41 and 8.39 keV. This note relates this observation to the differences in electron density at the nucleus in atomic and molecular hydrogen and points out that the enhancement at high photon energies is unique for molecular hydrogen.

16133. Ekberg, J. O., **Term analysis of Fe VI,** *Phys. Scr.* **11,** No. 1, 23-30 (1975).

Key words: iron; spectra; ultraviolet; wavelengths.

The spectrum of Fe VI has been observed by using a vacuum sliding-spark discharge and the 10.7-m grazing-incidence spectrograph and the 10.7-m normal-incidence spectrograph at the National Bureau of Standards, Washington. More than 400 lines have been classified in the region 250-1 580 Å. All terms of the configurations $3d^3$, $3d^24s$ and $3d^24p$, except $3d^2(^1S)4s^2S$ have been established. The estimated uncertainty of the level values is ± 0.4 cm^{-1}. The $3d^3$, $3d^24s$ and $3d^24p$ level structure has been theoretically interpreted. The energy parameters determined from a least-squares fit of the observed level values are compared with Hartree-Fock calculations. From the complete set of $3d^3$ levels all forbidden lines of Fe VI from 1,387 to 10,000 Å have been predicted. All but two lines in the spectrum of the star RR Telescopii previously identified as forbidden Fe VI lines have been confirmed and 6 of the otherwise unexplained lines have been identified as [Fe VI].

16134. Epstein, G. L., Reader, J., **Spectrum of doubly ionized yttrium (Y III),** *J. Opt. Soc. Am.* **65,** No. 3, 310-314 (Mar. 1975).

Key words: spectra; ultraviolet; wavelengths; yttrium; zirconium.

The spectrum of doubly ionized yttrium was observed from 600 to 9700 Å by means of plane- and concave-grating spectrographs at NBS. About 100 new lines were observed. From these measurements, 40 new energy levels were derived. The known level system (Rb I isoelectronic sequence, $4p^6nl$) now includes the series ns (n=5-9), np (n=5-9), nd (n=4-8), nf (n=4-10), ng (n=5-8), and nh (n=6-8). The nf series shows irregular fine-structure splittings, $4f$ having a negative splitting of about 3 cm^{-1}. The ionization energy of Y III was determined to be 165 540.5 $\pm$ 1.0 cm^{-1} (20.52457 $\pm$ 0.00012 eV). A re-examination of Kiess's data for Zr IV in the light of the Y III analysis yielded a revised value for the ionization energy of Zr IV of 277 550 $\pm$ 20 cm^{-1} (34.412 $\pm$ 0.003 eV).

16135. Geist, J., Dewey, H. J., Lind, M. A., **Low-level periodic pulsed energy measurements with an electrically calibrated pyroelectric detector,** *Appl. Phys. Lett.* **28,** No. 4, 171-173 (Feb. 15, 1976).

Key words: electrically calibrated pyroelectric detector; gold-black; piezoelectric; pulse laser power.

The use of an electrically calibrated pyroelectric detector for accurately measuring periodically pulsed (~3-ns duration) energy with an average power level in the microwatt to milliwatt range was investigated. Sources of error especially important in this application were the pyroelectric's acoustic response, its linearity, and possible deterioration of its gold black coating. The detector had a thin polymer film that isolated the radiation receiver from the pyroelectric material. This film temporally resolved the pyroelectric response from the piezoelectric response to the acoustic energy that is associated with the absorption of an impulse of energy. Thus it was demonstrated that the acoustic response was not a serious source of error. The film also reduced the requirement of linearity on the pyroelectric transducer by about 5 orders of magnitude from the conditions of a bare transducer. It is concluded that periodic pulsed energy measurements with 5 percent uncertainties are readily achievable with the detector described.

16136. Meisters, M., **Concepts and trends in polymer fire testing,** *Mod. Plast.* **52,** No. 9, 76-78, 81-82 (Sept. 1975).

Key words: fire performance tests; flame spread; heat input; heat release rate; limiting oxygen index; radiant panel; smoke density; time to ignition.

This report provides a framework for understanding the principles that are important in correlating small- and large-scale tests in terms of such fire concepts as ignition, propagation, heat

release, and smoke generation. All of the methods have limitations and cannot completely evaluate fire performance, but they offer a baseline for continued development of tests to provide better correlations with real-fire performance.

16137. Hamilton, W. C., Edmonds, J. W., Tippe, A., Rush, J. J., **Methyl group rotation and the low temperature transition in hexamethylbenzene. A neutron diffraction study,** *Discuss. Faraday Soc.* **48,** 192-204 (1969).

Key words: barrier to rotation; crystal; crystal structure; hexamethylbenzene; hindered rotation; phase transition; torsional oscillation; λ-point.

Neutron diffraction studies of single crystals of hexamethylbenzene at 298 K and at 130 K indicate that the molecule in phase II has approximate D_{3d} symmetry. The amplitudes of libration of the methyl group and of rigid body motions of the molecule are consistent with earlier data, except that the barrier to methyl group rotation appears to be lower by about 0.5 kcal/mol (2100 J/mol).

Consideration of intra- and inter-molecular hydrogen atom contact distances and calculated potential energy curves using a 6-exp potential function suggest that intermolecular forces are important in determining the barrier to rotation of the methyl groups and that substantial changes in the intermolecular packing must be responsible for the lambda-point transition at 116 K and the consequent profound change in the potential barrier to internal rotation which has been previously observed.

16138. Tsai, D. H., MacDonald, R. A., **Molecular dynamical studies of energy transport in a crystalline solid,** (Proc. Symp. on Computer Simulation for Materials Applications, Gaithersburg, MD, Apr. 10-21, 1976), *Nucl. Metall.* **20,** Pt. 1, 489-509 (Apr. 1976).

Key words: anharmonic crystal; computer simulation; energy transport; heat pulse; interatomic potential; molecular dynamics; second sound; shock wave; stress wave; temperature wave; thermal diffusivity; thermal relaxation.

We review the main results of a series of molecular dynamical studies of the transport of energy in a crystalline solid subjected to heating and to shock compression. Our model is a perfect semi-infinite bcc lattice. We use a two-body interatomic potential which simulates that in α-iron. The classical equations of motion for the atoms are solved numerically under appropriate initial and boundary conditions, and the properties of the lattice and the transport of energy are determined from averages of the atomic motion. We find that a disturbance in thermal energy propagates either by diffusion or as a temperature wave with second sound velocity. A disturbance in potential energy propagates as a stress wave with first sound velocity. These results are in agreement with experiments. In addition, we find that longitudinal and transverse stress waves generate their own temperature waves through thermalization of the kinetic energy change accompanying the stress disturbances. The significance of this thermal relaxation process to the interpretation of heat pulse and shock wave experiments is examined.

16139. Tovey, H., **The development of the National Fire Data System,** *Fire J.* **68,** No. 6, 91-96 (Nov. 1974).

Key words: fire data; fire hazard; fire injuries; fire investigation; fire loss; fire reporting; fires.

The development of the National Fire Data System is described. The major policy requirements established for the system are listed, and four specific categories of fire data needs are defined. The system itself is described in terms of inputs, structure, and outputs, and the system users are classified and described. A report on the current status of the system development effort is given, covering projects on the fire incident reporting subsystem, the national household survey of fire experience, statistical summary data tapes, fire technology information, detailed hazard analyses, and integrated system outputs.

16140. Young, R. D., **Instrumentation for the chemical analysis of manufactured surfaces,** *Ann. CIRP* **24,** No. 2, 549-554 (Aug. 1975).

Key words: surface; surface finish; surface roughness measurement.

Over the last twenty years a wide variety of analytical instruments for studying the chemical composition of surfaces have been developed, many of which are commercially available. Several of these instruments lend themselves to the analysis of the practical surfaces encountered in manufacturing processes, thus contributing to our understanding of the process, and the integrity of the fabricated surface.

Three particularly useful techniques include ESCA, Auger and the electron microprobe. In ESCA (electron spectroscopy for chemical analysis) nearly monochromatic x-rays of about 1000 eV energy impinge on the specimen surface. Photoelectrons produced in atoms of the top nanometer are energy analyzed to yield spectra which are characteristic of these surface atoms. In the Auger technique, high-energy electrons bombard the specimen surface, generating Auger electron emission which is characteristic of the surface atoms. This instrument if often combined with LEED (low energy electron diffraction), enabling measurement of the atomic arrangement of the surface atoms which are analyzed with Auger emission.

A highly attractive though less well developed technique called infrared reflection (absorption) could conceivably be used on-line to detect the presence of certain chemicals on surfaces. The scanning electron microscope (SEM) has been combined with the electron microprobe (EMP) in order to determine the micro-distribution of materials over a surface. In the microprobe a high energy electron beam stimulates characteristic x-ray emission from surface atoms. Application of these techniques to fabricated surfaces will be discussed.

16141. Edelman, S., **Piezoelectric polymer stress gages,** *Proc. Symp. on Advancements in Instrumentation for Civil Engineering Applications, Kirtland Air Force Base, NM, May 9-10, 1973,* Technical Report No. AFWL-TR-73-186, pp. 221-224 (Air Force Weapons Laboratory, Kirtland Air Force Base, NM, Oct. 1973).

Key words: piezoelectric; polymeric transducer; polymers; polyvinyl fluoride; polyvinylidene fluoride; stress gages; transducers.

Gradual improvement in material selection and poling techniques has developed polymers with significant piezoelectric activity. This material can now be used to make many kinds of instruments for measuring dynamic stress, pressure, vibration, etc. Polymers that can be made piezoelectrically active are available with a wide variety of mechanical, electrical, and chemical properties. They can be formed in size and shape to suit a particular application and they can be fastened to curved, twisted or compliant surfaces. Sensors in the form of thin sheets, coaxial cables, and hollow tubing have been made.

16142. Eliason, L. K., **Standards for door security,** *Archit. Met.* **21,** No. 3, 6-7 (June 1976).

Key words: building codes; door assemblies; performance requirements; physical security; standards.

This article discusses the need for standards for the physical security of door assemblies, describes the nature and application of NILECJ-STD-0306.00, "Physical Security of Door Assemblies and Components," and suggests the manner in which the standard can be utilized to improve the security of door assembly components. The implementation of the standard within local building codes is also addressed.

16143. Evans, J. M., Jr., **Position sensors and computer control techniques for automatic control of agricultural vehicles,** *Proc. IFAC Symp. on Automatic Control for Agriculture, Saskatoon, Saskatchewan, Canada, June 18-20, 1974*, Dr. G. C. Zoerb, Ed., Preprint Sec. A-2, pp. 1-5 (Agricultural Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, 1974).

Key words: agriculture; computer control; position sensors; RF interferometer.

RF interferometers may be used for determination of position and orientation of vehicles to an accuracy of millimeters over distances to thousands of meters. Servo control may be implemented through mini- or micro-computers using read-only memory for the control functions. The application of these techniques to the control of agricultural vehicles is discussed.

16144. Krasny, J. F., **Development of flammability standards,** *Proc. 3d Symp. on Textile Flammability, New York, NY, Apr. 16-17, 1975*, pp. 30-46 (LeBlanc Research Corp., East Greenwich, RI, 1975).

Key words: apparel; burn injury; carpets; draperies; fabrics; flammability; heat flux; standards; tents; tests; uniforms; upholstered furniture.

The activities of the Center for Fire Research of the National Bureau of Standards in the area of textile item flammability standards are described. Work is in progress on a general apparel flammability standard, to replace CS 191-53. A test concept involving a cylindrical fabric specimen, and measurement of the ignitability and the heat release to the inside of the cylinder, is under development. A draft standard for the flammability of upholstered furniture was submitted to the Consumer Product Safety Commission. It consists of a fabric-screening test and test of mock-ups of the fabric, stuffing, tape, etc., arranged as in the furniture piece to be tested. A flooring systems test, to provide a reasonable substitute for the tunnel test, is applicable also to carpets. It consists of exposing a sample to radiation varying in intensity over the specimen length. The specimen is pilot ignited at the high radiation end, and the distance burned until the flames extinguish is measured. This distance can be converted to the "critical radiant flux" as a measure of potential hazard. Studies are also in progress on curtains and draperies, tents, and flight attendant uniforms.

16145. McHenry, H. I., **Ship steel weldments for low temperature service,** *Weld. J.* **55,** No. 5, 387-393 (May 1976).

Key words: alloying; inclusions; low temperature; rolling; ships; steel; welding.

The ship steels, welding practices and weldment toughness requirements applicable to low temperature (to −46 °C) regions of liquefied-natural-gas (LNG) tankers are reviewed. In the construction of LNG ships, the principal welding productivity problem is the low deposition rate associated with the low heat input welding practices required to provide sufficient toughness in the weld heat-affected-zone (HAZ). A potential solution to this problem is to use improved steels which can be welded using efficient procedures and still provide satisfactory HAZ toughness. The steelmaking practices that contribute to low temperature toughness are reviewed with respect to economic limitations associated with ship steels and to their potential for improving HAZ toughness.

16146. Meissner, P., Evans, J. M., **Computer-aided design in manufacturing,** (Proc. Technology Workshops, Lafayette, IN, Oct. 3-6, 1973 and Columbus, OH, Nov. 7-10, 1973), Paper in *The Automation Research Council*, A. Seireg, Ed., Report No. 5, pp. 289-303 (The American Automatic Control Council, Holmdel, NJ 07733, Feb. 1974).

Key words: CAD; CAD/CAM; computer-aided design; manufacturing.

This review of the use of computer-aided design in manufacturing is based primarily on the experiences of General Motors, McDonnell Douglas, and the Army Electronics Command. The paper provides a common base for discussions by representatives of Government, industry, and universities attending two Workshops on the Technologies of Automation sponsored by the Automation Research Council of the American Automatic Control Council. The material illustrates the current state-of-the-art in CAD, including available hardware and software, and the economics and time savings of existing CAD systems.

16147. Mitchell, R. A., Woolley, R. M., Baker, S. M., **Finite element simulation of weldbonded joint deformation,** (Proc. Symp. on Computer Simulation for Materials Applications, Gaithersburg, MD, Apr. 19–21, 1976), *Nucl. Metall.* **20,** Pt. 2, 1039–1050 (Apr. 1976).

Key words: bonded joints; computer simulation; cyclic loading; debond analysis; finite element analysis; joints; nonlinear analysis; single-lap-joint bending; spotwelded joints; weldbonded joints.

Finite element computer techniques are described that simulate the structural response of weldbonded single-lap and double-lap joints. The techniques also apply equally well to the special case of a bonded joint without spotwelds. A planform analysis articulates the in-plane deformation of the joined sheet material and the lap-shear stresses acting through the spotwelds and the adhesive. A longitudinal cross-section analysis computes out-of-plane bending effects, particularly important in single-lap joints, and adhesive peel stresses. Algorithms are described that simulate several nonlinear modes of response by sequences of linear solutions. Single-lap joint specimens of eight different configurations, designed so as to constitute an experimental parameter study, were instrumented with resistance strain gages and tested in the laboratory. For the most part, strains measured on the surfaces of these specimens were in reasonably good agreement with the finite element simulations, provided out-of-plane bending effects were accounted for.

16148. Collard, J. J., **Is the proposed Federal Standard for brakes adequate for police patrol vehicles?,** *Proc. SAE Automotive Engineering Congress and Exposition, Detroit, MI, Feb. 24-28, 1975*, Paper No. 750399, pp. 1-6 (Society of Automotive Engineers, Inc., Warrendale, PA, 1975).

Key words: FMVSS 105a; LAPD brake tests; NBS survey; patrolcar brakes; patrolcar survey; police brake requirements.

In 1972, the National Bureau of Standards surveyed 530 police departments to determine what was wrong with their patrolcars: 449 departments responded to the survey. Thirty-two percent of the respondents, a plurality, identified brakes as the most dangerous feature, and 36 percent identified it as the system most in need of standards. Ninety-four percent of the respondents rated their patrolcar brakes excellent to satisfactory at speeds under 70 mph (113 kph), but 25 percent rated them poor

over 70 mph. While the new Federal Motor Vehicle Safety Standard 105-75 may improve the brake systems for patrolcars for routine, low speed use with frequent applications, it will be necessary to continue testing patrolcar brakes under severe driving conditions to assure reliability at high speeds.

16149. Krasny, J. F., Francis, J. B., **Ranking extinguishability of burning fabrics,** *J. Am. Ass. Text. Chem. Color.* **6,** No. 6, 135-136 (June 1974).

Key words: cotton fabrics; extinguishability; flammability; polyester/cotton fabrics.

This report describes initial efforts to obtain laboratory data on the relative extinguishability of various fabrics, an aspect of the hazard due to burning fabrics which has been largely neglected in the past. A simple apparatus was designed to simulate the extinction of burning fabrics by beating the flames out. Two plates covered with asbestos sheeting are brought together at a rapid rate after a fabric suspended between them comes to a full burn. The time the plates have to be held together to extinguish the flames was found to increase roughly with increasing fabric weight. For a given weight, the time to extinguish tended to be shorter for all-cotton fabrics than for polyester/cotton blends; the blends also tended to stick to the plates.

16150. Parker, W. J., **The large-scale fire-test facility at the National Bureau of Standards,** *Proc. Symp. on Full-Scale Fire Tests, Lancaster, PA, Nov. 11-12, 1974*, pp. 45-48 (1976).

Key words: construction; corridor test; fire endurance furnace; fire growth; heat release; smoke abatement; sprinkler system.

The newly completed fire-test facility at the Gaithersburg site of the National Bureau of Standards provides the capability of studying the fire endurance of columns, walls, and floor/ceiling assemblies; fire growth and control in rooms; fire spread and control in corridors; and smoke movement in buildings. The study of fire growth in a room is concentrated on the role of the furnishings, as well as the interior finishing materials. A burn room is also available to examine the fire-buildup process in a large item of furniture.

16151. Reed, W. P., **Radioisotope and radiopharmaceutical standards,** *Proc. San Diego Biomedical Symp., San Diego, CA, Feb. 6-8, 1974*, **13,** 507-509 (1974).

Key words: biomedical; clinical; measurements system; radioisotopes; radiopharmaceuticals; reference sources; standards; SRM's.

A previous paper by J. P. Cali described meaningful measurements and the components that go into a meaningful measurement system. This paper examines one of the NBS programs in the measurement system and how this system relates to the biomedical profession.

At NBS the Radioactivity Section under the supervision of Dr. W. B. Mann is responsible for relating our national measurement system and standards for radioactivity to the international measurement system. This activity has three aspects of interest here: (1) SRM's that are available to all and are related to the national measurement system. (2) An industry-government cooperative program for the improvement and standardization of commercial radiopharmaceuticals and other reference sources. (3) A training and interlaboratory comparison program for the education of clinical personnel in the measurement of radioactive materials, including the calibration of devices commonly used to measure radiopharmaceutical doses.

These three aspects of this program help to stabilize the measurement system, i.e., help to make meaningful measurement. Each of these efforts is discussed in detail to improve the understanding of interactions between the national laboratory and laboratories or groups in the field making these measurements, and to clarify the interaction between individuals and the system.

16152. Powell, F. J., Kusuda, T., Hill, J. E., **Occupant comfort as a decision-making concept for air conditioning of buildings,** (Proc. CIB Commission W45 (Human Requirements) Symp. on Thermal Comfort and Moderate Heat Stress, Watford, England, Sept. 13-15, 1972), Paper in *Thermal Comfort and Moderate Heat Stress*, pp. 191-215 (Her Majesty's Stationery Office, London ECIV 3RN, England, 1973).

Key words: air conditioning criteria; human comfort; physiological indices; predicted indoor habitability index (PIHI); weather building human systems.

A rationale for improving air-conditioning criteria is given. A new research approach and concept are presented. The concept is to include in criteria the effect of the building envelope and the response of humans to the resultant indoor temperature and relative humidity in addition to weather data which are normally used to make decisions concerning air conditioning for buildings. The concept involves generation of a "Predicted Indoor Habitability Index" (PIHI) as a means to evaluate the response of occupants to short-term as well as long-term exposure in non-air-conditioned housing. The work completed thus far is described.

The results of a pilot study for two locations, Jersey City, New Jersey and Macon, Georgia, are presented to demonstrate the feasibility of the concept. The indoor temperature and humidity were determined by calculation using a computerized simulation technique which follows a detailed heat transfer analysis of the weather/building/human-body systems. The calculated results were used to compute the value of several available physiological indices to reveal the extent and duration of undesirable indoor conditions when the apartment was not air conditioned. Statistical correlations between indoor and outdoor conditions were prepared as a means to reduce the amount of computation for establishing criteria.

16153. Schaefgen, J. R., **Integrating community utilities for resource conservation,** *Proc. Third National Conf. on Complete Water Reuse: Symbiosis as a Means of Abatement for Multi-Media Pollution, Cincinnati, OH, June 27-30, 1976*, pp. 53-59 (1976).

Key words: community services; cooling; electric power; energy conservation; heating; incineration; integrated utility systems; resource conservation; utilities; utility services; water reuse.

A Modular Integrated Utility System (MIUS) provides the utility services of electrical power, space heating and cooling, potable water heating, solid waste processing, sanitary sewage treatment, potable water treatment, and the site distribution, collection, and disposal functions attendant thereto. MIUS facilities are constructed on a community scale to achieve the maximum symbiotic effects from process integration. The MIUS approach to utility services can conserve energy, reduce environmental degradation, and permit greater flexibility in intensive land development at a competitive cost. A demonstration design is being initiated to quantify the performance and evaluate the synergistic benefits of multi-service facilities.

16154. Slater, P. J., **Leaves of trees,** (Proc. 6th Southeastern Conf. on Combinatorics, Graph Theory, and Computing, Boca Raton, FL, Feb. 17-20, 1975), Paper in *Proceedings of the Sixth Southeastern Conference on Combinatorics, Graph Theory, and Computing*, F. Hoffman, R. C. Mullin, R. B. Levow, D. Roselle, R. G. Stanton, and R. S. D. Thomas, Eds.,

pp. 549-559 (Utilitas Mathematica Publishing Inc., Winnipeg, Manitoba, Canada, 1975).

Key words: block-cutpoint tree; graph; tree; 2-connected.

If v is a vertex of degree at least three in a tree T and at least one branch at v is a path, then the subgraph of T consisting of the union of all such branch paths at v is called a leaf of T. There are infinitely many trees T with a given leaf structure (of two or more leaves), but certain of their parameters, such as the number of edges it is necessary to add to T to produce a 2-connected graph, are the same. Simple formulas are given for some of these parameters.

16155. Thomson, R., Fuller, E., **Crack morphology in relatively brittle crystals,** (Proc. Symp. on Fracture Mechanics of Ceramics, University Park, PA, July 11-13, 1973), Paper in *Fracture Mechanics of Ceramics*, R. C. Bradt, D. P. H. Hasselman, and F. F. Lange, Eds., **1**, 283-295 (1973).

Key words: fracture; lattice trapping; slow-crack growth; stress corrosion.

From the viewpoint that cracks are atomically sharp, general outlines are given for some of the types of theories which should be developed for such cracks. The existence of atomic cleavage in a large class of materials is argued on the basis of the stability of a crack under spontaneous dislocation formation. A qualitative description of lattice trapping of a cleavage crack is given which correlates the effect to the atomic force laws. The determining factor for the observation of lattice trapping is the width of the cohesive region of the crack "core." Finally, a qualitative model of slow crack growth due to environmental effects is developed in terms of atomic dissolution at the crack tip.

16156. Wachtman, J. B., Jr., **Emerging priorities in ceramic engineering and science—Viewpoint of the scientist-engineer,** (Proc. Conf. on Emerging Priorities in Ceramic Engineering and Science, Alfred, NY, Nov. 4-6, 1974), Paper in *Ceramic Engineering and Science*, V. D. Frechette, L. D. Pye, and J. S. Reed, Eds., pp. 37-50 (Plenum Publishing Corp., New York, NY, 1974).

Key words: ceramics; educational priorities; energy; engineer-scientist; environmental quality; materials; minerals.

The role of the scientist-engineer regarding application of technology to national problems is discussed. The probable physical and social "environment" of the future scientist-engineer is assessed. Promising areas of ceramic science are discussed in broad terms. Some educational priorities are recommended.

16157. McNesby, J. R., **The role of standard reference materials in environmental measurements,** *Proc. National Conf. on Health, Environmental Effects, and Control Technology of Energy Use, Washington, DC, Feb. 9-11, 1976, Report No. 600/776-002*, pp. 58-60 (U.S. Environmental Protection Agency, Washington, DC, 1976).

Key words: air and water quality; energy; pollutants; standard reference materials.

The rationale for the importance of accurate as well as precise environmental measurement is presented. The role of Standard Reference Materials is to provide the analyst with NBS certified samples to facilitate his ability to make accurate measurement. Available energy related Standard Reference Materials are listed and those expected to be developed along with target dates are tabulated.

16158. Freeze, P. D., Thomas, D. B., **Studies of noble-metal thermocouple stability at high temperatures,** *NASA CR-135055*, 54 pages (National Aeronautics and Space Administration, Washington, DC, July 1976).

Key words: aging; calibration change; gradient; high temperature (700 to 2000 °C); iridium; iridium-rhodium alloy; noble-metal thermocouple; oxidation; platinum; platinum-rhodium alloy; preferential oxidation; temperature gradient; thermal gradient; thermocouple; thermoelectric stability.

This report describes two investigatory studies on performance characteristics of noble-metal thermocouples: (1) thermoelectric stability as affected by preferential oxidation of iridium in the system iridium-40 percent rhodium versus iridium, and (2) the effects of temperature gradients on the performance of the systems platinum-13 percent rhodium versus platinum and iridium-40 percent rhodium versus iridium, operating in air.

The stability investigation was carried out at three temperatures—1700, 1850, and 2000 °C—by comparing the output of the test thermocouple in air with the output of an identically constructed test-reference thermocouple in nitrogen. The results show that no calibration shift was observed producing a change in output greater than that corresponding to a 2.0 percent change in the test temperature.

The investigation of gradient effects was carried out by subjecting test thermocouples to both severe and mild gradients. For the platinum system, the operating temperature was 1500 °C with gradients of 1475 and 700 °C/cm; for the iridium system, 2000 °C with gradients of 700, 1500, and 1975 °C/cm. Exposure to temperature gradients was found to introduce significant changes in calibration for both systems.

In both investigations, the thermoelements were examined by means of electron-probe analysis and by metallographic methods to detect chemical and structural changes. Data and micrographs are presented.

16159. Meier, M. M., **Neutron standards at the National Bureau of Standards,** *Proc. Third Conf. on Application of Small Accelerators, North Texas State University, Denton, TX, Oct. 21-23, 1974*, CONF-741040-P1 **1**, 365-370 (Available from the National Technical Information Service, VA 22161, 1975).

Key words: associated particle technique; neutron detector; neturon flux monitor; neutron standards; neutrons; $T(p,n)^3He$ reaction.

The neutron standards program at NBS is discussed with emphasis on Van de Graaff contributions to the overall program. In particular, the characteristics of an associated particle apparatus, which serves as a primary standard for flux normalization at the three percent accuracy level are presented. The "black" detector, a secondary standard, suitable as a flux monitor for linac applications and for dosimetry is characterized and its calibration with the associated particle technique is described. Future goals of the program are outlined and the Van de Graaff/associated particle system's future role in achieving them are discussed.

16160. Friauf, R. J., Young, K. F., Merz, W. J., **Properties of ionic crystals,** Paper 9f in *American Institute of Physics Handbook, Third Ed.*, pp. 9-74—9-127 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: crystals; ionic conductivity; ionic crystals; properties of ionic crystals.

16161. Frederikse, H. P. R., **Properties of semiconductors,** Paper 9e in *American Institute of Physics Handbook, Third Ed.*, pp. 9-56—9-74 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: band structure; properties of semiconductors; semiconductors; thermoelectric power.

16162. Frederikse, H. P. R., Slater, J. C., **Electronic properties of solids,** Paper 9c in *American Institute of Physics Handbook, Third Ed.*, pp. 9-26–9-38 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: distribution function; electronic properties of solids; energy band.

16163. Frederikse, H. P. R., **Structure, melting point, density, and energy gap of simple inorganic compounds,** Paper 9b in *American Institute of Physics Handbook, Third Ed.*, pp. 9-16–9-25 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: density; energy gap; inorganic compounds; melting point; structure.

16164. Wiese, W. L., Glennon, B. M., **Atomic transition probabilities,** Paper 7i in *American Institute of Physics Handbook, Third Ed.*, pp. 7-200–7-209 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: aluminum; argon; atomic transition probabilities; beryllium; boron; carbon; chlorine; helium; hydrogen; lithium; magnesium; nitrogen; oxygen potassium; sodium.

16165. Beaty, E. C., Persson, K. B., **Electrical conductions in gases,** Paper 5e in *American Institute of Physics Handbook, Third Ed.*, pp. 5-138–5-139 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: conduction; electrical conduction in gases; gases.

16166. Harris, F. K., **Electrical standards,** Paper 5c in *American Institute of Physics Handbook, Third Ed.*, pp. 5-107–5-119 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: absolute electrical standards; electrical standards; electrical units.

16167. Hilsenrath, J., **Thermodynamic properties of gases,** Paper 4h in *American Institute of Physics Handbook, Third Ed.*, pp. 4-162–4-204 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: air; argon; hydrogen; ionized gases; nitrogen; oxygen; thermodynamic properties.

16168. Furukawa, G. T., Douglas, T. B., **Heat capacities,** Paper 4e in *American Institute of Physics Handbook, Third Ed.*, pp. 4-105–4-118 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: entropy; heat capacity; molar heat capacity.

16169. Powell, R. L., Childs, G. E., **Thermal conductivity,** Paper 4g in *American Institute of Physics Handbook, Third Ed.*, pp. 4-142–4-162 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: conductivity; thermal conductivity.

16170. Greenspan, M., **Acoustic properties of liquids,** Paper 3e in *American Institute of Physics Handbook, Third Ed.*, pp. 3-86–3-98 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: acoustic properties of liquids; acoustics; Knester liquids; normal liquids; sound.

16171. McKinney, J. E., Lindsay, R., **Density and compressibility of liquids,** Paper 2l in *American Institute of Physics Handbook, Third Ed.*, pp. 2-148–2-187 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: compressibility; density; liquid compressibility; liquid density.

16172. Stegun, I. A., **SI units,** Paper 1b in *American Institute of Physics Handbook, Third Ed.*, pp. 1-8–1-13 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: metric; SI symbols; SI units.

16173. Stegun, I. A., Carter, C., **Mathematics bibliography,** Paper 1a in *American Institute of Physics Handbook, Third Ed.*, pp. 1-2–1-8 (McGraw-Hill Book Co., New York, NY, 1972).

Key words: bibliography; indexes; mathematics bibliography.

16174. Frederikse, H. P. R., Hosler, W. R., Loeffler, N. L., **Testing and test analysis of MHD-materials,** *Proc. NSF-OCR Engineering Workshop on MHD-Materials, Cambridge, MA, Nov. 20-22, 1974*, pp. 138-149 (1974).

Key words: high temperatures; materials evaluation, MHD-materials; test procedures.

The problem of materials development for MHD-power generation is two-fold: The materials to be used in the channel, the combuster, the air-preheater, etc., must have the appropriate electrical and thermal characteristics and at the same time possess sufficient mechanical strength and chemical stability to withstand the very severe environmental conditions for periods of 1000-10,000 hours. This paper will discuss the test conditions in small and medium sized MHD-generators and the evaluation of the tested materials. The results of two short tests performed on 4 electrode materials in the UTSI-MHD-facility will be described and the conclusions drawn from these tests will be summarized.

16175. Albus, J. S., Evans, J. M., Johnsen, E. G., **A hierarchical concept for man-machine communication,** (Proc. 18th Annual Meeting of the Human Factors Society, Huntsville, AL, Oct. 15-17, 1974), Paper in *Benefits for Mankind*, E. L. Saenger and M. Kirkpatrick, III, Eds., pp. 506-509 (The Human Factors Society, Santa Monica, CA, Oct. 1974).

Key words: adaptive control; computer control; control theory; hierarchical control; man-machine communication and automation.

The problem of man controlling or programming a machine may be considered as a hierarchy of control functions, with each level of control calling up ordered sequences of operations at the next lower level, using appropriate sensory feedback for each level. Man may enter the control hierarchy at any level for direct control or for programming an automatic system for later playback. The computer carries out lower level control functions, thereby augmenting man's control capabilities.

The Cerebellar Model Articulation Controller (CMAC) is a computer based control system in which high-level task-oriented commands can be broken down into a series of elemental motor actuator signals. CMAC is a general purpose adaptive control concept which can be arranged in a hierarchical structure, such as that described above, so as to facilitate the man-machine communication problem. For example, CMAC can solve the coordinate transformation problem so that commands can be given in terms of desired end point trajectories. Furthermore, CMAC can handle many feedback variables such as measurements of misalignment of parts, variable mass loading, irregularities in materials, and constraints imposed by an external environment.

16176. Lyons, J. W., **Requirements for fire safety of combustible materials in the United States,** *Proc. Int. Symp. on Fire Safety*

of Combustible Materials, Edinburgh, Scotland, Oct. 15-17, 1975, **1**, 12-25 (1975).

Key words: fire codes; fire research; fire safety.

Fire safety of buildings and building furnishings in the United States is controlled by local codes and certain mandatory Federal requirements. The test methods and criteria used in codes generally are developed by technical committees of ASTM or NFPA. In a typical development these tests are first incorporated in the NFPA Life Safety Code, then in the four model building codes before finding their way into local codes. An alternative mechanism is inclusion in a mandatory Federal requirement as, for example, in the standards for housing insured by the Department of Housing and Urban Development, for nursing homes supported by the Department of Health, Education and Welfare, hospitals run by the Veterans Administration, or transportation vehicles regulated by the Department of Transportation. Test methods for these Federal agencies are developed by Federal research, often at the Center for Fire Research at the National Bureau of Standards.

The fire safety of consumer products falls under the purview of the Consumer Product Safety Commission. Test methods for CPSC are developed in two ways: by offerors in the private sector under provisions of the Consumer Product Safety Act of 1972, or by Federal research, for example at NBS.

There is great concern in the United States about the chaotic situation with regards to the validity of fire test methods. The focus on fire safety has in recent years shifted from fire endurance and compartmentation (which concepts apply to large buildings and are not helpful in single-family residences) to concern for the occupants in the room of origin and in single-family residences. This means we are now concerned with furnishings and interior finish materials. Tests for these items need considerable work. There is no one small test which permits one to assess the fire safety of a furnished enclosure. (The Federal Trade Commission has underscored this with a recent action against the advertising and promotional claims made based on results of small tests.) Current research efforts are directed to developing standardized full-scale fire tests for enclosures and improved correlations between these and small-scale economical tests. Active roles in this research are being played by the Center for Fire Research, Committee E-39 on Fire Hazard Standards in ASTM, and the Products Research Committee, established as part of a consent order between the FTC and a number of plastics manufacturers.

Fire research in the United States has received new impetus from the Federal Fire Prevention and Control Act of 1974. This Act established a new National Fire Prevention and Control Administration in the Department of Commerce and established anew the research on fire at the National Bureau of Standards. The Center for Fire Research at NBS has a new, broader assignment including its traditional research on fire phenomena and adding a major new responsibility for studies on the effects of fire on its victims (biological, physiological and psychological aspects).

The Fire Administration will be developing new equipment for fire fighting, detection, and suppression as well as helping to improve the efficiency and safety of fire fighting, helping with fire prevention and protection by performing code evaluation and assisting community planning and attacking public indifference through education. With this new emphasis and support at the Federal level, one hopes that United States fire losses will decrease in the future to come into line with fire losses of the other industrial nations of the world.

16177. Blanc, R. P., **Assisting network users with a network access machine,** *Proc. Annual Conf. of the Association for Computing Machinery, San Diego, CA, Nov. 11-13, 1974*, **1**, 74-84 (Association for Computing Machinery, New York, NY, 1974).

Key words: access procedures; computer networks; macros; minicomputers.

Accessing networks of heterogeneous computer systems can often be cumbersome due to differences in command languages and conventions. Approaches toward improving these conditions are identified and a specific solution—a "Network Access Machine"—is described in detail. The "Network Access Machine" is a minicomputer-based system that acts as a network access point for a user at his terminal and assists the user through the automatic execution of access procedures. This minicomputer facility allows the user to specify (or to have specified) his own network commands. The minicomputer expands these commands into command sequences executable on a specified network and host connected to that network. Further, system and network responses are analyzed to assure agreement with those anticipated for specific commands. Conditional and parameterized expansions allow the use of the same commands on different host computers and different networks.

16178. Breden, L. H., Meisters, M., **The effect of sample orientation in the smoke density chamber,** *J. Fire Flammability* **7**, 234-247 (Apr. 1976).

Key words: fire performance; horizontal and vertical smoke measurements; smoke; smoke density chamber; smoke suppressants.

Smoke measurements were compared for various materials in the vertical and horizontal positions. There appeared a significant difference for thermoplastic materials because of the melting away from the incident heat flux in the vertical position. The horizontal mode in addition allows one to relate the chemistry of polymeric materials to the amount of smoke production. Finally, smoke measurements are made of products containing various amounts of smoke suppressants.

16179. Bright, R. G., **Early warning fire detection,** *Proc. Fire Protection in Interior Design, Cleveland, OH, Apr. 10-11, 1975*, pp. 170-184 (1975).

Key words: atriums; fire detection; flame detectors; heat detectors; hospitals; hotels; maintenance; nursing homes; reliability; schools; smoke detectors.

A description of the specialized signatures of fire conditions along with a description of the various available fire detectors are presented. Some special problems of fire detectors such as reliability and maintenance are discussed. The paper closes with a discussion of specialized applications of fire detection to open plan office buildings, atriums, schools, buildings with smoke control systems and the use of detectors in corridors.

16180. Pease, R. L., Galloway, K. F., Stehlin, R. A., **Radiation damage to integrated injection logic cells,** (Proc. IEEE Nuclear and Space Radiation Effects Conf., Eureka, CA, July 14-17, 1975), *IEEE Trans. Nucl. Sci.* **NS-22,** No. 6, 2600-2604 (Dec. 1975).

Key words: digital bipolar circuits; integrated injection logic; radiation damage; radiation effects.

The effects of neutron and total dose gamma irradiations on the electrical characteristics of an integrated injection logic (I^2L) cell and an I^2L multiple inverter circuit were investigated. These units were designed and fabricated to obtain circuit development information and did not have radiation hardness as a goal. The following parameters of the test structures were measured as a

function of total dose and neutron fluence: the dc common-base current gain of the lateral *pnp* transistor; the dc common-emitter current gain of the vertical *npn* transistor; the forward current-voltage characteristics of the injector-substrate junction, and the propagation delay versus power dissipation per gate for the multiple inverter circuit. The limitations of the present test structures in a radiation environment and possible hardening techniques are discussed.

16181. Maki, A. G., Freund, S. M., **Laser Stark measurements on OCS including the observation of zero-field-forbidden $\Delta J = 0, \pm 2$ transitions,** *J. Mol. Spectrosc.* **62,** 90-98 (1976).

Key words: carbonyl sulfide; dipole moments; infrared; lasers; spectra; spectroscopy; Stark effect.

Laser Stark measurements have been made on the $02^{0}0\text{-}00^{0}0$ and $03^{1}0\text{-}01^{1}0$ vibrational transitions of $^{16}O^{12}C^{32}S$, $^{16}O^{12}C^{34}S$, and $^{18}O^{12}C^{32}S$, and on the $03^{1}0\text{-}01^{1}0$ transition of $^{16}O^{13}C^{32}S$, using a CO_2 laser. In addition to providing dipole moment information for excited vibrational states, these measurements give vibrational band centers accurate to several megahertz. To aid in optical pumping experiments, several near coincidences between CO_2 laser transitions and OCS absorption lines are discussed. Electric-field-allowed $\Delta J = 0$ transitions are observed for the $2\nu_2$ band of $^{16}O^{12}C^{32}S$ and $^{16}O^{12}C^{34}S$, as well as $\Delta J = 2$ transitions for the same band of $^{18}O^{12}C^{32}S$.

16182. Caswell, R. S., Coyne, J. J., **Neutron energy deposition spectra studies,** (Proc. 4th Symp. on Microdosimetry, Verbania Pallanza, Italy, Sept. 24-28, 1973), Paper in *Fourth Symposium on Microdosimetry,* J. Booz, H. G. Ebert, R. Eickel, and A. Waker, Eds., EUR 5122 d-e-f, pp. 967-979 (Commission of the European Communities, Luxembourgh, Mar. 1974).

Key words: energy deposition spectra; microdosimetry; neutron interactions with tissue; neutrons; radiation quality; secondary particle spectra; theoretical dosimetry.

Secondary particles (p, α, C, N, etc.) are generated when neutrons interact with tissue. We are concerned with three spectra of these secondary particles: (1) the "initial" spectra which come from neutron cross section information, (2) the "slowing-down spectra" which are obtained from the initial spectra and secondary particle stopping power data, and (3) the "energy deposition spectra"—the spectra of energy depositions by the secondary particles in small tissue volumes, which depend upon both the previous spectra, the geometrical properties of the volume, and upon stopping power and range information. We have calculated all of these spectra for a number of energies of monoenergetic neutrons between 60 keV and 14 MeV using analytic methods previously described. Examples will be given of the variation of the spectra and of certain spectral averages such as the frequency and dose averages of lineal energy ($\bar{y}_f, \bar{y}_D$) as a function of neutron energy. Experimental information for comparison exists for spectra of type (3), and we understand measurements of spectra of type (1) are underway.

16183. Gross, D., **The measurement and correlation of fire growth in a room,** *Proc. Symp. on Full-Scale Fire Tests, Lancaster, PA, Nov. 11-12, 1974,* pp. 77-87 (Research and Development Center, Lancaster, PA, 1976).

Key words: buildings; fire growth; flame spread; heat release; interior finish; reduced scale modeling; room corner tests; smoke.

Evaluation of fire growth in a room requires characterization of the source fire, defining a measure of full fire involvement, and correlation in terms of small-scale laboratory tests. A series of 20 room-corner tests was performed using a wood-crib ignition source and selected combinations of interior-finish materials on wall and ceiling surfaces. The upper room-gas temperature was taken as a measure of fire-growth level and potential involvement of all combustible contents. Comparisons are presented between results of the full-scale tests and available laboratory tests on the interior-finish materials. Supplementary approaches involving analytical and reduced-scale modeling are also discussed.

16184. Hust, J. G., Schramm, R. E., **Density and crystallinity measurements of liquid and solid *n*-undecane, *n*-tridecane, and *o*-xylene from 200 to 350K,** *J. Chem. Eng. Data,* **21,** No. 1, 7-11 (1976).

Key words: cryogenics; crystallinity; density; expansion; paraffins.

Densities of solid and liquid *n*-undecane, *n*-tridecane, and *o*-xylene are reported for temperatures from 200 to 350K. Density increases upon freezing by 13, 13, and 12 percent, respectively, for these hydrocarbons. The data are presented graphically and are also represented by equations to within the scatter of the data. The uncertainties of the data are 0.2 percent for the liquid and 1 percent for the solid state. X-ray examinations revealed that these materials have complex crystalline structures when frozen. Near 200K the main crystal structure is orthorhombic, but several phase transformations occur for each of these materials between 200K and the melting point.

16185. Richmond, J. C., **Courtroom of the future. Court related use of videotape recordings,** (Proc. Seminar on Civil Trial Advocacy, University of Kentucky, Lexington, KY, Jan. 23-24, 1976), Paper in *Report of Seminar on Civil Trial Advocacy,* pp. 43-45 (Office of Continuing Legal Education, University of Kentucky, Lexington, KY, July 1976).

Key words: closed circuit television; court proceedings; court security; trial proceedings; videotape recording.

The presentation consisted of showing the videotape "Courtroom of the Future," plus showing slides giving more detail about certain features of the Courtroom of the Future at the McGeorge School of Law in Sacramento, California. The equipment for recording trial proceedings on video, and precautions for court security were emphasized.

16186. Richmond, J. G., **The courtroom of the future,** (Proc. 8th Annual Crime Countermeasures Conf., Lexington, KY, Apr. 15-19, 1974), Paper in *Proc. 1974 Carnahan and Int. Crime Countermeasures Conf., UKY BU* **105,** 152 (Aug. 1974).

Key words: closed circuit television; court proceedings; court security; trial proceedings; videotape recording.

The presentation consisted of showing the videotape "Courtroom of the Future," plus showing slides giving more detail about certain features of the Courtroom of the Future at the McGeorge School of Law in Sacramento, California. The equipment for recording trial proceedings on video, and precautions for court security were emphasized.

16187. Bright, R. G., **Regulations and standards concerning fire detection systems in the United States,** *Proc. 7th Int. Seminar on Problems in Automatic Fire Detection, Aachen, Germany, Mar. 5-6, 1975,* pp. 47-60 (Institut für Elektrische Nachrichtentechnik, Aachen, Germany, 1975).

Key words: fire detection; regulations; smoke detectors; United States standards.

Historically, fire detection systems for the protection of people and property from fire have not enjoyed wide usage in the U.S. With respect to property protection the emphasis has been

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on the use of automatic sprinkler systems as opposed to automatic fire detection systems. This trend is likely to continue for the foreseeable future. It is in protecting people from fire that automatic fire detection is receiving ever increasing attention.

The U.S. loses an inordinate number of people each year in fires. As most of this loss-of-life takes place in the family life unit, more and more of the U.S. regulatory agencies are requiring the inclusion of automatic fire detection devices, primarily smoke detectors, in all new family living units. This includes apartments, single-family dwellings, and mobile homes.

The paper describes the trends evident in these regulations. The paper also describes the type of smoke detection devices required by these regulations, some of the shortcomings evident in the presently available smoke detectors, and the status of testing and approval standards used to judge the suitability of smoke detectors for life safety.

16188. Unassigned.

16189. Clifton, J. R., **Protection of reinforcing bars with organic coatings,** *Mater. Perform.* **15,** No. 5, 14-17 (May 1976).

Key words: bridge decks; chloride ions; corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars.

Results of a program aimed at identifying organic coatings suitable for steel reinforcing bars in concrete are given. Resistances of candidate coatings to abrasion, solutions of calcium chloride, hydroxide, sulfate, and fresh cement paste, and surface preparation of steel, resistance of coated bars to electrical currents, and concrete-to-coating bonding are discussed. Tests were made on liquid and powdered epoxy, polyvinylchloride liquid, polypropylene powder, phenolic nitrile liquid, and zinc rich liquid coatings.

16190. Treado, M. J., **Development of reports and guidelines for law enforcement communications equipment,** (Proc. 8th Annual Crime Countermeasures Conf., Lexington, KY, Apr. 16-19, 1974), Paper in *Proc. 1974 Carnahan and Int. Crime Countermeasures Conf., UKY BU* **105,** 102-112 (Aug. 1974).

Key words: communications; digital communications; guideline; law enforcement equipment report, Law Enforcement Standards Laboratory; mobile digital equipment; National Institute of Law Enforcement and Criminal Justice.

The Law Enforcement Standards Laboratory (LESL) was established by NBS for the National Institute of Law Enforcement and Criminal Justice (NILECJ) primarily to develop performance standards to assist law enforcement agencies in their equipment selection and procurement process. In addition to performance standards, LESL also is developing equipment reports, guidelines and glossaries for use by the law enforcement community. This paper uses a typical study effort, in this case one on mobile digital communications, to illustrate the development of a law enforcement equipment report.

16191. Schramm, R. E., Reed, R. P., **Stacking fault energies of fcc Fe-Ni alloys by x-ray diffraction line profile analysis,** *Metall. Trans. A* **7A,** No. 3, 359-363 (Mar. 1976).

Key words: invar; iron alloys; nickel alloys; stacking fault energy; x-ray diffraction.

The stacking fault energies of the fcc alloy series Fe-28 Ni to pure Ni were investigated using x-ray diffraction line profile analysis. A minimum stacking fault energy of about 70 mJ/m² occurs at the approximate composition of Fe-40 pct Ni. From this point, the lower nickel alloys rapidly increase to a very high stacking fault energy, estimated to be 200 mJ/m², while the energies of the high Ni alloys rise linearly to the Ni value of 214 mJ/m². Anomalous reductions of the lattice parameter after cold work were found for the low nickel alloys; this was interpreted as evidence for Fe_3Ni ordering and corrections to the stacking fault energy were made.

16192. McNeil, J. R., Collins, G. J., Persson, K. B., Franzen, D. L., **Ultraviolet laser action from Cu II in the 2500-Å region,** *Appl. Phys. Lett.* **28,** No. 4, 207-209 (Feb. 15, 1976).

Key words: Cu II spectrum; ultraviolet laser, 250.0 nm.

We have obtained cw laser action from Cu II at 2486, 2506, 2591, and 2599 Å by exciting a neon discharge in a copper hollow cathode. We have observed 7-mW cw output power just above threshold and the output appears to saturate at 210 mW under quasi-cw operation. The four ultraviolet laser lines observed originate from the $3d^9 5s(^3D)$ term of Cu II. The quantum efficiency of the 2500-Å laser transitions approaches 25 percent. Each of the four Cu II laser transitions has been employed in the past by spectroscopists as a secondary wavelength standard in the ultraviolet.

16193. Andrews, J. R., Lawton, R. A., **Electrically strobed optical waveform sampling oscilloscope,** *Rev. Sci. Instrum.* **47,** No. 3, 311-313 (Mar. 1976).

Key words: laser; optical pulse; oscilloscope; photoconductor; pulse measurements; sampling.

A new instrument for measuring optical waveforms is described. It is an optical sampling oscilloscope employing a GaAs photoconductive sampling gate and an electrical sampling strobe. The basic theory of operation is derived. A 100-psec risetime rudimentary prototype has been built and results of measurements of a GaAs laser diode pulse are presented.

16194. Tobler, R. L., Read, D. T., **Fatigue resistance of a uniaxial S-glass/epoxy composite at room and liquid helium temperatures,** *J. Compos. Mater.* **10,** 32-43 (Jan. 1976).

Key words: cryogenics; fatigue; fiber composites; liquid helium; low temperature tests; mechanical properties.

Tension-tension axial fatigue tests of a uniaxial glass filament-reinforced epoxy were conducted at 295 K and 4 K. The fatigue life was found to be an order of magnitude greater at 4 K than at 295 K. These results are believed to be the first 4 K fatigue data reported for a composite material.

16195. Dalke, J. L., **Metric system versus anthropomorphic units—A bicentennial coup?,** *Am. Metric J.* **4,** No. 3, 121-123 (1976).

Key words: anthropomorphic units; bicentennial; history of measurement; metric conversion; metric roll call; metrology; Public Law 93-380; Public Law 94-168.

The U.S.A. declared its independence in 1776. The Bicentennial Anniversary of this occasion ironically also is the beginning of a stronger commitment to discard our cumbersome customary English measurement system, an action that is already well underway in English speaking countries. The English system now persists most strongly in the U.S., yet in addition to its inconsistencies it is to our economic disadvantage to continue the use. Public Law 94-168, the Metric Conversion Act of 1975, which became effective December 23, 1975, provides a mechanism for promoting the metric system in the U.S. Thus, in 1976, the Bicentennial year, we begin to push more sharply for independence from a measurement system that is becoming obsolete. A synopsis is given of the development of anthropomorphic measurements and an overview of metric (SI) usage in the U.S., including a metric "roll call" of industry.

16196. Clark, A. F., Haynes, W. M., Deason, V. A., Trapani, R. J., **Low temperature thermal expansion of barium ferrite,** *Cryogenics* **16,** No. 3, 267-270 (May 1976).

Key words: barium ferrite; low temperature; thermal expansion.

The linear thermal expansion of polycrystalline barium ferrite, $BaFe_{12}O_{19}$, was measured from 76 to 293 K both parallel and perpendicular to the magnetization direction. An anisotropy of about 15-20 percent was observed. The results match well the available data above room temperature and have also been extrapolated to 0 K.

16197. Richmond, J. C., **Criteria for evaluating image quality of night vision devices,** (Proc. 8th Annual Crime Countermeasures Conf., Lexington, KY, Apr. 16-19, 1974), Paper in *Proc. 1974 Carnahan and Int. Crime Countermeasures Conf., UKY BU* **105,** 83-94 (Aug. 1974).

Key words: acutance; contrast transfer function; edge gradient; image quality; light equivalent background; light induced background; limit resolution; line spread function; optical transfer function; point spread function.

The National Bureau of Standards is developing Standards for image intensifier night vision devices for use in law enforcement, under a project managed by the Law Enforcement Standards Laboratory of NBS, which is sponsored by the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Agency of the Department of Justice. The quality of the image produced by such a device is an important measure of its utility, and image quality criteria are an important part of such a Standard. Many variables contribute to image quality, not all of which have been identified, or can be measured. This paper is a literature survey of criteria and techniques that have been used to evaluate the quality of imaging systems, with some discussion of their application to image intensifier night vision devices.

16198. Rockett, J. A., **Who will design fire protection of the future,** *Society of Fire Protection Engineers, Technical Report 75-5,* pp. 1-5 (Society of Fire Protection Engineers, Boston, MA, 1975).

Key words: fire protection; future trends; professional qualifications.

The professional cross section of fire protection engineers of a decade from now is discussed. Present trends in the field are projected and it is suggested that a much broader and richer set of professional backgrounds will be found.

16199. Stokesberry, D. P., Hasegawa, S., **Automatic digital microwave hygrometer, model II,** *Rev. Sci. Instrum.* **47,** No. 5, 556-558 (May 1976).

Key words: digital microwave hygrometer; hygrometer, digital microwave; microwave, digital, hygrometer.

A "ruggedized" microwave hygrometer which requires no moving parts in the basic measurement method is described. It is designed to measure atmospheric humidity over the vapor pressure range 3-7400 pascals (Pa) (0.03-74 millibar).

16200. McDonald, D. G., Johnson, E. G., Harris, R. E., **Modeling Josephson junctions,** *Phys. Rev. B* **13,** No. 3, 1028-1031 (Feb. 1, 1976).

Key words: cryogenics; electronic tunneling; Josephson effect; superconductivity.

The current-voltage characteristic of a current-biased junction is calculated using the Werthamer theory. In contrast with the voltage-biased model large zero-frequency currents exist at 0 K at all bias voltages below the energy gap and the Riedel peak is directly displayed. The effect of capacitance on the *I-V* curve is described and the form of the subharmonic energy-gap structure is calculated using the Mattis-Bardeen model for the superconducting electrodes.

16201. Rockar, E. M., Forman, R. A., **Fe^{4+} ($3d^4$) optical absorption in oxidized $SrTiO_3$,** *Phys. Status Solidi A Short Notes* **33,** K91-K95 (1976).

Key words: charge transfer, color centers; crystal field; d^4 ions; EPR; iron 4+; optical absorption; perovskite; strontium titanate; transition metal; zero phonon line.

The optical absorption spectrum of oxidized, iron doped $SrTiO_3$ at 10 K exhibits a sharp line at 772.5 nm (12,945 cm^{-1}) with side bands at $\Delta\nu_1 = 116$ cm^{-1}, $\Delta\nu_2 = 168$ cm^{-1}, and $\Delta\nu_3 = 315$ cm^{-1}. After moderate reduction in flowing H_2 at 900 °C this line and its vibronics disappear. The spectrum is attributed to the $^5E_g \rightarrow {}^3T_{tg}$ transition of $Fe^{4+}(3d^4)$.

16202. Howard, C. J., Evenson, K. M., **Rate constants for the reactions of OH with ethane and some halogen substituted ethanes at 296 K,** *J. Chem. Phys.* **64,** No. 11, 4303-4306 (June 1, 1976).

Key words: fluorocarbons; hydroxyl radical; reaction rate constants.

Absolute rate constants for the reactions of OH radicals with C_2H_6 and twelve fluorine, chlorine, and bromine substituted ethane compounds are reported. The measurements are made at 296 K and pressures ranging from 100 to 1000 Pa (0.7-7 torr) using a discharge-flow system and laser magnetic resonance detection of OH. The results are similar to those of an earlier work on a series of methane compounds and indicate that the reaction mechanism is the abstraction of an H atom. Thus, completely halogenated molecules are relatively inert. The hydrogen containing molecules react with rate constants ranging from about 3 to 400×10^{-15} cm^3 $molecule^{-1} \cdot sec^{-1}$.

16203. Ogburn, F., **Electrodeposition and government laboratories,** *Plating Surf. Finish.* **63,** No. 7, 24-29 (July 1976).

Key words: Blum, William; electrodeposition; government laboratories; plating.

Government laboratories have made numerous contributions to the science and technology of electrodeposition in the form of commercial instruments and process as well as engineering data and scientific information. These laboratories and their more significant contributions are briefly reviewed as seen through the eyes of one Government scientist.

16204. Birky, M. M., **Philosophy of testing for assessment of toxicological aspects of fire exposure,** *J. Combust. Toxicol.* **3,** 5-23 (Feb. 1976).

Key words: bioassay; combustion products; fire; hazard assessment; toxicity.

Detailed investigation of fire fatalities and autopsies of fire victims indicate the interaction of carbon monoxide, pulmonary injury, alcohol and cardiovascular disease in fire fatalities that are attributed to smoke inhalation. Laboratory assessment of the toxicity hazard of combustion products has relied predominantly on chemical analysis for a few selected toxic gaseous species such as carbon monoxide. While the clinical data suggest that carbon monoxide has been the predominant toxicant in past fatalities, the advent of new synthetic materials that contain fire retardants or are inherently more fire resistive have the potential

of contributing other unknown toxicants. In addition, the particulate phase (smoke) may play a major role in inhalation toxicity that cannot be assessed by means of chemical analyses. In the past the toxicity of some new fire retardants has been screened using feeding experiments. While this is an important first step, experiments to determine the inhalation toxicity of the thermal degradation products, of the fire retardants and of polymers incorporating fire retardants must also be made to assess the acceptability of such materials.

This paper proposes that a multi-disciplinary program, including toxicological, chemical and combustion expertise, is required to assess the toxicological effects of combustion products. The product mixture is so complex that a toxicity assessment will require animal exposures combined with analysis of selected gases and correlation with biomedical information.

16205. Rosenstock, H. M., **The measurement of ionization and appearance potentials,** *Int. J. Mass Spectrom. Ion Physics* **20,** 139-190 (1976).

Key words: appearance potential; gaseous positive ions; heat of formation; ionization potential; measurement.

Measurement techniques and methods of data interpretation leading to ionization potentials, appearance potentials and heats of formation of gaseous positive ions are summarized and critically discussed. Special attention is paid to defining the accuracies, problems and limitations of the techniques and interpretations. References have been selected and cited which discuss these matters in more detail.

16206. Hust, J. G., **Thermal conductivity standard reference materials, Progress Report,** (Proc. XIII Int. Conf. on Thermal Conductivity, Lake of the Ozarks, MO, Nov. 5-7, 1973), Paper in *Advances in Thermal Conductivity*, R. L. Reisbig and H. J. Sauer, Jr., Eds., pp. 22-24 (1974).

Key words: austenitic steel; cryogenics; electrical resistivity; electrolytic iron; Lorenz ratio; thermal conductivity.

Current and past research in the area of standard reference materials is described. New characterization data for SRM's 734 and 735 (thermal conductivity standard reference materials) are discussed. Low temperature thermal conductivity data for sintered tungsten are included in anticipation of establishing this material as a thermal conductivity standard reference material. Present indications are that SRM 734 (electrolytic iron) may be extended to temperatures as high as 800 °C and SRM 735 (austenitic stainless steel) may be extended to 100 °C as thermal conductivity standard reference materials. It appears that tungsten may be used to temperatures as high as 2700 °C.

16207. Daney, D. E., **Turbulent natural convection of liquid deuterium, hydrogen and nitrogen within enclosed vessels,** *Int. J. Heat Mass Transfer* **19,** No. 4, 431-441 (Apr. 1976).

Key words: cryogenics; heat transfer; hemisphere; horizontal cylinder; liquid deuterium, liquid hydrogen, liquid nitrogen; natural convection; sphere; vertical cylinder.

Quasi-steady natural convection of liquid deuterium, hydrogen, and nitrogen within a sphere, hemisphere, horizontal cylinder, and vertical cylinder has been studied experimentally for the case of a nearly uniform wall temperature. A single expression relating the Nusselt and Rayleigh numbers,

$$Nu = 0{\cdot}104\, Ra^{0.352},$$

fits the deuterium and nitrogen data over the range $7 \times 10^8 < Ra < 6 \times 10^{11}$, while the hydrogen Nusselt numbers are 8 percent lower. The temperature field within the vessels is virtually free of horizontal temperature gradients. A single dimensionless temperature profile characterizes the vertical temperature distribution for each vessel shape, with the profiles for the sphere, hemisphere, and horizontal cylinder being nearly identical.

16208. Siegwarth, J. D., **A high conductance helium temperature heat switch,** *Cryogenics* **16,** No. 2, 73-76 (Feb. 1976).

Key words: gold plating; heat switch; He temperature; high conductivity.

Metallic contact heat switches with high thermal conductances have been designed and tested in the 4 to 15 K temperature range. Both gold plating and solid silver were used for the contact surfaces. Switch conductances greater than 1W K^{-1} at 15 K were achieved for a switch closed at this temperature with a force of 54 kg. The conductance is proportional to temperature, and varies approximately as the 2/3 power of the closing force.

16209. Weiss, A. W., **Transition probabilities for ionized atoms,** (Proc. 4th Int. Conf. on Beam-Foil Spectroscopy, Gatlinburg, TN, Sept. 15-19, 1975), Paper in *Beam-Foil Spectroscopy*, I. A. Sellin and D. J. Pegg, Eds., **1,** 51-68 (Plenum Publishing Corp., New York, NY, 1976).

Key words: ions; oscillator strengths; quantum mechanics; spectroscopy; transition probabilities; wave functions.

Several aspects of the line strength problem for ionized atomic systems are discussed. Level crossings, which arise from the restructuring of the ionic spectrum, occur frequently in the medium stages of ionization and can produce severe irregularities in the f-value behavior along an isoelectronic sequence. Calculations on several such examples are described. For very highly ionized species relativistic effects must be taken into account, and the hydrogen-like line strengths are discussed as a prototype of orbital relativistic effects. For many-electron systems the major relativistic effect is intermediate coupling, and multi-configuration calculations including the dominant Pauli approximation corrections have been done on a number of ions. Results are presented for the beryllium and boron isoelectronic sequences.

16210. Larsen, E. B., Andrews, J. R., **Using fiber optics in a broadband, sensitive, isotropic antenna—15 kHz to 150 MHz,** *Proc. IEEE Int. Symp. on Electromagnetic Compatibility, Washington, DC, July 13-15, 1976,* pp. 385-389 (Institute of Electrical & Electronics Engineers, Inc., New York, NY, 1976).

Key words: broadband antenna; electromagnetic compatibility; fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe.

A broadband, active, isotropic receiving antenna was developed at NBS for the frequency range 15 kHz to 150 MHz. It was designed for use with a conventional receiver to measure weak, near-zone electric fields of unknown polarization, such as leakage emanations from electronic equipment placed within a shielded enclosure. The antenna system consists of three mutually-orthogonal active dipoles, each 31 cm long by 3 cm diameter. The entire frequency range of each of the three field components is amplified and used to modulate a high-speed light emitting diode (LED) located inside the dipole. The modulated infrared (IR) signals are guided through glass fibers 10 meters long which connect the "isolated" dipoles to avalanche photodiodes at the far end of the fiber guides. These photodetectors recover the RF modulation from the IR carrier for input to the receiver. The fiber-optic antenna system described in this paper has high sensitivity (down to 10 μV/m) and fast response time (RF modulations up to 150 MHz). The readout indication at each receiver frequency is proportional to the Hermitian magnitude of E, which is the root-sum-square value of three orthogonal E field components at the measurement point.

16211. Torchia, D. A., Lyerla, J. R., Jr., Quattrone, A. J., **A ^{13}C magnetic resonance study of the helix and coil states of the collagen peptide αl-CB2,** (Proc. Rehovot Symp. on Poly(Amino Acids), Polypeptides, and Proteins and Their Biological Implications, Israel, May 1-8, 1974), Paper in *Peptides, Polypeptides and Proteins*, E. R. Blout, F. A. Bovey, M. Goodman, and N. Lotan, Eds., pp. 436-448 (John Wiley & Sons, New York, NY, 1974).

Key words: collagen; conformation; correlation times; cyanogen bromide peptides; polypeptides; relaxation times; rotational diffusion; ^{13}C magnetic resonance.

Carbon-13 chemical shifts, spin-lattice (T_1) and spin-spin (T_2) relaxation times and ^{13}C-^1H nuclear Overhauser enhancements (NOE) have been determined for the coil and triple helical states of the αl-CB2 fragment of rat skin collagen. Assignment of all aliphatic resonances of this 36 residue peptide in the random coil state (30°) has been achieved with the aid of model polypeptides containing pyrrolidine residues. The T_1 measurements show that the interior backbone carbons of the coil are characterized by effective rotational correlation times (τ_{eff}) of *ca.* 0.45 nsec. while sidechain and near terminal backbone τ_{eff} values are 2-5 times shorter. These results along with the narrow natural linewidths (3-5 Hz) and maximum NOE values (3.0) demonstrate the high degree of backbone segmental motion and sidechain mobility in the unordered state of the peptide. By contrast, the broad lines (50-80 Hz) and low NOE values (1.3) for the α-carbons in the helical state (2°) suggest much slower motion. These results together with the T_1 values (0.025-0.040 sec) are consistent with a model in which the motion of the ordered state of αl-CB2 is described by rotational diffusion of an axially symmetric rigid ellipsoid having dimensions approximating those expected for a collagen-type helix of 36 residues.

16212. Sweeney, W. T., **Dental research at the National Bureau of Standards 1919-1969,** *Br. Dent. J.* **127,** 289-290 (Sept. 16, 1969).

Key words: amalgam; composite materials; dental gold alloys; dental research; panoramic x ray; silicate cement; turbine handpiece.

The dental research program started at NBS in 1919 has continued as a joint effort with the cooperation of the American Dental Association, the National Institute of Dental Research, the U.S. Army, the U.S. Air Force, and the Veterans Administration. The staff of about 35 is made up of Research Associates, Guest Workers, and employees of the National Bureau of Standards. Approximately 500 papers have been published on dental materials, including amalgam, gold alloys, cements, denture base materials, and on research related to natural tooth structure. Materials and instruments, including the high speed turbine handpiece and the panoramic x-ray machine developed at NBS, have made major contributions to the practice of dentistry.

16213. Coriell, S. R., Sekerka, R. F., **The effect of the anisotropy of surface tension and interface kinetics on morphological stability,** *J. Cryst. Growth* **34,** No. 2, 157-163 (July 1976).

Key words: alloys; anisotropy; interface kinetics; solidification; stability; surface tension.

The theory of the morphological stability of a planar interface during solidification of a binary alloy has been modified to account for an anisotropic departure from local equilibrium (anisotropic interface kinetics) at the solid-liquid interface. The temperature for local equilibrium is calculated from the Gibbs-Thomson equation for anisotropic surface tension. Departure from local equilibrium is characterized by taking the interface velocity to be a function of thermal undercooling, concentration, orientation, and curvature. A perturbation analysis leads to the conclusion that an isotropic departure from local equilibrium causes a modification of the capillary terms and liquidus slope as they enter the expression for the time evolution of perturbations; in addition, perturbation growth rate is retarded. Allowance for anisotropy of surface tension causes the capillary terms to depend on direction. Anisotropic interface kinetics leads to the additional important effect that sinusoidal perturbations are translated parallel to the unperturbed interface as they change in amplitude. The peaks of such sinusoidal perturbations will therefore grow at an angle to the normal of the unperturbed interface. This effect is believed to be an underlying cause for the existence of preferred directions for cellular and dendritic growth.

16214. Truhlar, D. G., **Interpretation of ortho-para hydrogen conversion,** *J. Chem. Phys.* **65,** No. 3, 1008-1010 (Aug. 1, 1976).

Key words: chemical reactions; collision theory; hydrogen atoms; hydrogen molecules; indistinguishable particles; nuclear spin; rate coefficients; transition-state theory.

The interpretation of statistics of the nuclear spin states in the ortho-para hydrogen conversion by hydrogen atoms is considered. It is shown that the observable rate coefficient (which is the sum of the forward and reverse rate coefficients for Para→ortho conversion) equals the distinguishable-atom rate coefficient in the classical limit. In addition to spin-1/2 nuclei, we also consider spin-1 nuclei and spin-0 nuclei.

16215. Persensky, J. J., **Human factors in product safety research,** *ASHRAE Trans.* **81,** Part 2, 434-440 (Dec. 1975).

Key words: appliances; behavioral science; human factors; product safety; safety; safety research.

In 1955, the National Bureau of Standards (NBS) provided the basic human performance and reaction data necessary for the establishment of an appliance safety standard under the Refrigerator Safety Act of 1956. Between that time and the early 1970's, human factors aspects of product safety research have received little attention. Recently, however, the enactment of the Consumer Product Safety Act has provided a new impetus to product safety research. Members of ASHRAE should be particularly interested in the results of such research since a number of their products rank among the top products on the Consumer Product Safety Commission's (CPSC) list of hazardous products. Included are: space heaters, furnaces and water heaters. Unfortunately, almost no human factors data are available to serve the needs of safety motivated, product improvements. NBS has been working with CPSC since late 1973 and has established a program including human factors research to support the development of product safety standards. NBS will obtain human performance and reaction data related to the use of products in a naturalistic situation. In order to accomplish this, novel approaches to the collection of data are being developed.

This presentation describes some of the research. A generalized methodology involving critical incident and naturalistic observation techniques is presented. The presentation closes with illustrations of some of the problems associated with behavioral research.

16216. McBee, C. L., Kruger, J., **Events leading to the initiation of the pitting of iron,** (Proc. Int. Conf. on Localized Corrosion, Williamsburg, VA, Dec. 6-10, 1971), Paper in *Localized Corrosion*, R. Staehle, B. F. Brown, J. Kruger, and A. Agrawal, Eds., NACE-3, 252-260 (National Association of Corrosion Engineers, Houston, TX, 1974).

Key words: ellipsometry; iron; kinetics; optical constants; passive; pitting; spectroscopy.

Ellipsometric spectroscopy was used to analyze the changes in the passive film on Fe caused by chloride. The changes studied were the optical variations that take place in the film during the time period between introduction of chloride ions to the solution after passive film growth and the time just prior to breakdown.

It was found that the visible spectrum of the passive film on Fe at potentials above the critical pitting potential, E_p, is affected at only a few wavelengths when chloride is introduced into the solution in which the film is formed. At potentials below the critical pitting potential, the introduction of chloride produces optical changes at all wavelengths in the visible spectrum and can be interpreted as causing film thickening. Annealing the passive film grown above the critical pitting potential at 75 °C prior to the introduction of chloride produces the same results as that for films at potentials below E_p. Removal of chloride from the solution just prior to breakdown of the film results in a return of the optical parameters to the values found for a passive film.

The time to breakdown in chloride increases with increasing film thickness. The time for recovery of the passive state decreases with increasing film thickness. The overall concentration of chloride introduced in a film decreases with thickness for films grown at potentials above the critical pitting potential.

The results of this study point to a mechanism for passive film breakdown on Fe that requires a penetration of chloride via lattice defects.

16217. Scheps, R., Gallagher, A., **Teratomic recombination in alkali metal-noble gas vapors,** *J. Chem. Phys.* **65,** No. 3, 859-871 (Aug. 1, 1976).

Key words: alkali metal-noble gas vapors; gas vapors; metal-noble gas vapors; vapors, gas.

The teratomic recombination rates for the reaction $M^* + 2X \rightarrow MX^* (A^2\Pi) + X$ have been studied for Rb-Xe, Na-Ar, Ke, Xe, and Li-Ar, Kr, Xe. This analysis employs data and molecular potential determinations from earlier measurements where free alkali M was optically excited to M^* in the presence of noble gas X and the $MX^*(A^2\Pi) \rightarrow MX(X^2\Sigma)$ fluorescence resulting from teratomic recombination was measured. Collisional processes compete with radiative decay, so that in the low [X] limit where dissociation collisions are negligible the ratio of bound molecular to atomic photon emission gives the branching ratio between the molecular formation rate and the known atomic radiative rate. The molecular spectrum is observed as a continuum whose intensity profile may be used to infer a bound state vibrational distribution at each [X]. Both bound and quasibound states are included in this distribution, as both contribute to the observed molecular spectra. The low pressure limit of this distribution yields the teratomic recombination rate as a function of binding energy, and the total recombination rate constant k_f. It is generally found that this distribution per quantum state is almost independent of binding energy; i.e., the probability of molecular formation appears to be about the same for all bound states, it does not favor the highest bound levels. When the density of states is considered, weakly bound molecules are formed more frequently, but this weighting depends on the shape of the potential rather than the gas temperature. Comparison with theoretical models is made, and reasons for the discrepancies are discussed.

16218. Fanconi, B., **On the assignments of rotatory lattice modes in *n*-alkanes and polyethylene,** *J. Appl. Phys.* **46,** No. 10, 4124-4129 (Oct. 1975).

Key words: *n*-alkanes; polyethylene; Raman spectroscopy; rotatory lattice modes.

Considerable discrepancy exists in the recent literature on the assignments of the rotatory lattice modes of the *n*-alkanes and polyethylene. New low-temperature Raman data are presented on orthorhombic *n*-alkanes and on $n\text{-}C_{36}D_{74}$ and $n\text{-}C_{16}D_{34}$. Analyses of these data and the existing assignments show that the long-axis rotatory mode of the triclinic *n*-alkanes may be assigned to a weak Raman band at ~50 cm^{-1}; the A_g rotatory mode of polyethylene may be assigned to the Raman band at ~130 cm^{-1} and the B_{3g} rotatory mode to a weak Raman band at 108 cm^{-1}.

16219. Reneker, D. H., Fanconi, B., **Effects of defects on the longitudinal acoustic mode of *n*-alkane chains,** *J. Appl. Phys.* **46,** No. 10, 4144-4147 (Oct. 1975).

Key words: localized defects; *n*-alkanes; polyethylene; Raman-active longitudinal acoustic mode.

Normal mode calculations show that a single conformational defect in an otherwise all-trans *n*-alkane molecule disrupts the longitudinal acoustic mode (LAM) associated with the all-trans molecule. Similar calculations for a chain in the conformation produced by smoothly twisting a planar zigzag through 180° about the chain axis show that the LAM amplitudes and frequencies are unaffected by this gentle twist. These calculations indicate that the decrease in the LAM intensity observed in some polyethylene samples cannot be accounted for by smoothly twisted chains, but can be accounted for by defects which involve large localized departures from the all-trans conformation.

16220. Kusuda, T., Tsuchiya, T., Powell, F. J., **Prediction of indoor temperature by using equivalent thermal mass response factors,** (Proc. 5th Symp. on Temperature, Washington, DC, June 21-24, 1971), Paper in *Temperature, Its Measurement and Control in Science and Industry,* L. G. Rubin, A. C. Anderson, J. E. Janssen, and R. D. Cutkosky, Eds., Part 2, **4,** 1345-1355 (Instrument Society of America, Pittsburgh, PA, 1972).

Key words: on-line simulation of temperature controls; thermal response factors.

Several methods are explored for computing room temperature and room thermal load from outdoor conditions. An analytical method based upon rigorous heat transfer analysis of the building system requires a sophisticated computer program and a large computer. A stochastic time series method based upon experimental data of a limited time duration is attractive because it does not rely upon a complex heat transfer mathematics simulation. The stochastic processing of the experimental data, however, leads to the response factors which are physically inconsistent. A semiempirical method, based upon a finite difference solution of a differential equation modeling the equivalent thermal mass system, produced consistent and accurate results. Although this approach has only been verified using experimental data of very simple boundary conditions (without solar radiation effect and the internal heat generation), the results are very promising and encourage further study. Applications are mentioned, such as a simplified on-line computerized linear function temperature control system and, a means of predicting energy requirements for buildings.

16221. Moore, L. J., Gramlich, J. W., Machlan, L. A., **Application of isotope dilution to the high accuracy trace analysis of environmental and health standards,** (Proc. 9th Annual Conf. on Trace Substances in Environmental Health, Columbia, MO, June 11, 1975), Paper in *Trace Substances in Environmental Health-IX,* D. D. Hemphill, Ed., pp. 311-316 (1975).

Key words: cadmium; environmental Standard Reference Materials; isotope dilution; lead; molybdenum; rubidium; strontium; trace analyses.

During the last few years at the National Bureau of Standards, isotope dilution mass spectrometry (IDMS) has been extensively applied to the determination of trace elements in a variety of matrices. The cumulative result of recent developments in analytical methodology, such as the lowering of analytical blanks and thermal ionization enhancement techniques, has been the extension of the high accuracy capability of IDMS to more than 20 elements at the ppm (μg/g) and ppb (ng/g) levels with commensurate accuracies of 0.25–0.50 percent (relative ts, where $ts = t_{n-1}$ (0.95) sample standard deviation) for most of these elements. Applications of these techniques to selected elements in biological and environmental standard reference materials will be presented.

The efficacy of IDMS as a reference trace analytical tool is also being utilized for the development of accurate analysis techniques using the more frequently field-employed atomic absorption and emission spectrometry. This approach has been applied to Ca and Pb in porcine, bovine and human blood where the typical IDMS determinations are 0.1894 ± 0.0009 ppm and 84.09 ± 0.17 ppm for Pb and Ca, respectively. A brief comparison of these and comparable data from absorption and emission techniques will be presented.

16222. Luther, G. G., Towler, W. R., Deslattes, R. D., Lowry, R., Beams, J., **Initial results from a new measurement of the Newtonian gravitational constant,** (Proc. Atomic Masses and Fundamental Constants, Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., **5,** 592-598 (Plenum Publishing Corp., New York, NY, 1976).

Key words: acceleration measurement: fundamental constant; gravitational attraction; gravitational constant; rotating reference frame.

A redetermination of the Newtonian gravitational constant is underway at the National Bureau of Standards, Gaithersburg, Maryland, USA. This measurement is expected to yield results, eventually, in the 10 to 20 ppm range. An initial measurement with relatively low accuracy has been completed and some refinements are now in progress which show promise of better results.

16223. Deslattes, R. D., **Recent estimates of the Avogadro constant,** (Proc. Atomic Masses and Fundamental Constants, Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., **5,** 552-558 (Plenum Publishing Corp., New York, NY, 1976).

Key words: Avogadro; crystal; physical constant; x ray.

The present day situation of the Avogadro constant is reviewed. In the course of various recent adjustments, first the x-ray route and then the electrochemical Faraday had to be excised over the past several years. This then left a unique indirect electrical route which leads to a 6 ppm value. More recently, a new x-ray cell size, crystal density and atomic weight determination was carried out with 1 ppm claimed accuracy. The principal features of this are summarized.

16224. McCarter, R. J., **Smoldering of flexible polyurethane foam,** *J. Consum. Prod. Flammability* **3,** 128-140 (June 1976).

Key words: cotton; cushioning; fire retardant; furniture; glowing; inhibitor; oxidative pyrolysis; oxygen index; rayon; smoke; smoldering; upholstery fabric.

The smoldering behavior of various flexible polyurethane foams was studied. All foams smoldered when exposed to cigarette and fabric smolder, posing degrees of potential hazard. A few foams exhibited self-sustained smolder and were judged exceptionally hazardous.

Smolder behavior was compared to oxygen indices, density, permeability, and charring tendencies of the foams. A significant correlation was found between smoldering and charring (opposed to melting) tendencies. Distinctly different combustion behavior was noted for foams based on conventional polyols versus grafted polyols, and for foams containing fire retardant additives. Possibilities for modifying smolder behavior are discussed.

16225. Horowitz, E., **Plastics testing,** Paper in *Kirk-Othmer Encyclopedia of Chemical Technology, 2d Edition,* **15,** 811-832 (John Wiley & Sons, Inc., New York, NY, 1968).

Key words: nonpolymeric constituents in plastics; plastics testing; polymer analysis; properties; test methods.

Plastics are tested to measure one or more of their properties and to relate these measurements to predictable or observable behavior. These tests permit quality to be judged and the properties of plastics to be modified and improved. They also provide data on the fundamental nature and characteristics of plastics, which furthers our understanding of these systems. This chapter serves as an introduction to the subject of plastics testing and briefly describes some of the important tests that are made on plastic materials.

16226. Snell, J. E., **Summary Review—Evaluation factors, design requirements and needed research,** (Proc. Symp. CIB (Conseil Internationale du Batiment) Commission W62 on Water Supply and Drainage Inside Buildings, Watford, England, Sept. 19-20, 1972), Paper in *Water Demand in Buildings*, pp. 117-126 (Dept. of the Environment, Watford, England, Nov. 1973).

Key words: plumbing; plumbing research; water demand in buildings; water distributing systems.

This paper presents a framework for evaluation of water demands in buildings, which was used to review and summarize the papers presented at the Building Research Establishment Symposium on Water Demand in Buildings. This symposium was held in conjunction with the first meeting of CIB Commission W62 on Water Supply and Drainage.

This framework identifies prinicpal uses of water in buildings, the determinants of water demands, and the basic issues which must be addressed in developing improved predictive models and water supply and distributing system design procedures. Significant contributions in the symposium papers are noted, in particular experimental methodology and theoretical models.

The paper concludes by identifying important and relevant issues not addressed in the symposium papers and by summarizing needed research. Meaningful data on observed patterns of water use remain a major research need. Other needs include a more accurate and workable methodology for predicting future water demands and for design of water supply and distribution systems.

16227. Deslattes, R. D., Kessler, E. G., Sauder, W. C., Henins, A., **Visible to gamma-ray wavelength ratio,** (Proc. Atomic Masses and Fundamental Constants, Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., **5,** 48-53 (Plenum Publishing Corp., New York, NY, 1976).

Key words: crystal diffraction; gamma-ray wavelength; gold 198; goniometer; x-ray interferometry.

We report on procedures and a preliminary result for a measurement of the wavelength of the ^{198}Au 412 keV line relative to that of a molecularly stabilized laser in the visible. The measurement involves: optical interferometry of a Si lattice repeat distance; transfer from a sample of the Si crystal to Ge crystals;

and angle measurement for the γ-ray line diffracted by the Ge crystals by means of angle interferometry.

16228. Melmed, A. J., Carroll, J. J., **Three-color direct superposition for field-ion microscopy,** *J. Appl. Phys. Commun.* **47,** No. 8, 3762-3763 (Aug. 1976).

Key words: color superposition photography; field-ion microscopy; image analysis; three-color superposition.

Direct two-component color superposition for field-ion microscopy is extended to three-component color superposition. Details of the method are given and some applications are mentioned.

16229. Crawford, M. L., **Improved techniques and instrumentation for EMC measurements,** *Proc. IEEE Int. Symp. on Electromagnetic Compatibility, Washington, DC, July 13-15, 1976,* pp. 369-374 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: electromagnetic compatability; EMC instrumentation; measurements.

This paper presents a survey of improved measurement techniques, instrumentation, and data presentation for accurate, meaningful evaluation of electromagnetic compatibility (EMC) of electronic systems and subsystems. These techniques and instrumentation were developed as alternatives to conventional, MIL-STD-461/462, measurements which recommend screen room testing with conventional antennas. These alternatives are used to accurately measure and quantify EM emissions from electronic equipment and/or for establishing standardized EM susceptibility test fields. Dramatic improvement (worst case errors of 1 to 3 dB compared with 40 dB from conventional screen room measurements) have been demonstrated. The techniques described in the paper include: 1) low-Q or underground enclosures, 2) mode stirred, shielded enclosures, 3) specially designed, shielded, transverse electromagnetic (TEM) cells, 4) broadband field probes capable of measuring complex average or peak fields without causing perturbation, and 5) time and amplitude statistics for characterizing the measured data.

16230. Brown, W. E., Gregory, T. M., **Calcium pyrophosphate crystal chemistry,** *Arthritis Rheum.* **19,** No. 3, 446-462 (May-June 1976).

Key words: calcium diphosphate; calcium pyrophosphate; chondrocalcinosis; pseudogout; solubility; solubility product; synovial fluid.

Theoretical considerations governing the solubilities of calcium pyrophosphates are presented in terms of phase diagrams and calculations based on an ionic model, and the reliability of reported solubility data is examined in terms of the model. The solubility product constant, $(Ca^{2+})^2(P_2O_7^{4-})$, of $Ca_2P_2O_7 \cdot 2H_2O$ appears to be in the vicinity of 3×10^{-18}, but some of the data indicate that it may be as high as 10^{-14} to 10^{-13}. Recommendations are given for the future experimental measurements.

16231. Barbrow, L. E., **Changeover to metric—Timetable and Government role,** Paper in *Metrication—Managing the Industrial Transition,* R. G. Liptai and J. W. Pearson, Eds., Am. Soc. Test. Mater. Spec. Tech. Publ. 574, pp. 22-31 (July 1975).

Key words: conversion to metric; government metrication; metrication; metric system; SI; timetable for metrication.

The changeover to the metric system in the United States is motivated by our manufacturing industry. The basic reason for the changeover is economic necessity, which dictates also that changes to metric be made only where they are advantageous. In the transition timetable, our manufacturing industry and our educational institutions are already well started. Now, then, is the time also for the development of national metric engineering standards to supersede or supplement our customary engineering standards. Government procurement will keep in step with industry changeover. Consumer products will be changed some years hence, the specific time being dependent on the enactment of national metric legislation, but early programs should be initiated to keep our public informed as to why the changeover is taking place and how it is progressing. The principal role of Government in the changeover is to keep SI, the modernized metric system, as clean as possible. When metric legislation is enacted, a National Metric Conversion Board will have the responsibility for coordinating the changeover. Meanwhile the American National Metric Council has undertaken this role.

16232. Arp, V., **Negative differential flow resistance in supercritical helium,** *Cryogenics* **16,** No. 3, 171-177 (Mar. 1976).

Key words: flow resistance; helium; Ledinegg instability; negative flow resistance; supercritical helium.

The study of helium flow instabilities occurring in large helium cooling systems is important for the future development of these systems. One of these instabilities, the Ledinegg instability, is caused by negative differential flow resistance. This paper discusses the conditions under which a negative differential flow resistance can occur and finds that it will not occur in single phase helium cooling systems except under certain very restricted conditions.

16233. Benjamin, I. A., Adams, C. H., **The flooring radiant panel test and proposed criteria,** *Fire J.* **70,** No. 2, 63-70 (Mar. 1976).

Key words: fire hazard; fire safety; flooring test; radiant panel.

The objective of this discussion is to present background and other technical data that will help in suggesting criteria to be used in conjunction with the Flooring Radiant Panel Test to determine the potential contribution to fire growth of floor covering systems for use in corridors and exitways.

16234. Haller, F. B., Hessel, M. M., Neef, W., Lai, W., Lohr, H., **Concentric heat pipe cavity for e-beam excited lasers,** *Proc. 6th Symp. on Engineering Problems of Fusion Research, San Diego, CA, Nov. 17-21, 1975,* pp. 79-83 (Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: electron beam excitation; heat pipe oven; lasers; metal vapors; noble gas; spectroscopy.

A concentric heat pipe oven for metal vapor-noble gas mixtures has been designed and constructed as a high power laser cavity for laser fusion applications. A 1 MeV, 100 KA, 50 ns e-beam is injected into this oven through a stainless steel foil window, 0.125 mm thick. Details of the construction and design considerations of the heat pipe oven, foil window and safety features are given.

16235. Torchia, D. A., Lyerla, J. R., Jr., Deber, C. M., **Carbon-13 chemical shifts of amides and imino acid residues. Effects of the carbonyl substituent and** *syn-anti* **geometries,** *J. Am. Chem. Soc. Commun. to Editor* **96,** No. 15, 5009-5011 (July 24, 1974).

Key words: amides; carbon-13 magnetic resonance; chemical shifts; cis and trans isomers; peptides; proline; ring conformation; substituent effects.

Differences in C-13 chemical shifts, ΔC^i, for carbons *syn* and *anti* to the carbonyl oxygen ($\Delta C^i = \tau_{syn} - \tau_{anti}$) are reported for a series of N,N′-diethylamides and model peptides containing

imino acid residues. The model compound data show that cis and trans peptide bond isomers account for the ΔC^i values observed in polypeptides containing pyrrolidine residues (L-prolyl and hydroxyl-L-prolyl) when the effects of *syn-anti* geometry and the carbonyl substituent are considered.

16236. Allan, D. W., Mungall, A. G., Winkler, G. M. R., **Comments on the 25 April 1975 paper in "Science" entitled: "Terrestrial timekeeping and general relativity—A discovery,"** *Science* **191,** 489-490 (Feb. 6, 1976).

Key words: atomic clocks; clock acceleration effect; definition of the second; frequency accuracy; frequency standards; general relativity; gravitational redshift; primary frequency standards; proper time; UTC.

We wish to clarify some essential points relative to the paper "Acceleration and Clocks," by W. H. Cannon and O. G. Jensen. Cannon and Jensen have developed two contradictory equations based on different relativistic assumptions and have attempted to "resolve the contradictions" using data tabulated by the Bureau International de L'Heure (BIH) on atomic clocks located at various places in North America and Europe. The atomic clock data Cannon and Jensen have used are those for the UTC_i, where the *i* denotes the Observatory and/or Laboratory generating a particular Coordinated Universal Time Scale. We are obliged to state that Cannon and Jensen's assumption that "the intervals on the time scales UTC_i of the contributing Observatories... correspond to the adopted definition of the second" is not valid at the accuracy level they need to test the contradiction between their equations.

The experimental data used by Cannon and Jensen contain inaccuracies and systematic effects which render invalid their conclusion of "A Discovery" in general relativity. To the contrary, experimental data do exist which contradict Cannon and Jensen's conclusion that an "observer's" perception of the world geometry depends on his state of acceleration."

16237. Jones, R. N., **Electronic eavesdropping techniques and equipment,** *LESP-RPT-0207.00,* 40 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: body worn antenna; bugging; eavesdropping; electronic surveillance; microphones; receiver; tape recorder; telephone; transmitter; wiretapping.

This report describes some of the methods and equipment used for electronic audio surveillance. The subject of countersurveillance (defensive) equipment and techniques, while not completely excluded, is confined to the minimum necessary to the understanding of offensive surveillance activity. Both radiating and hard wire methods are discussed along with the advantages, disadvantages and limitations of each. Particular attention is given to the subject of body worn transmitters and the operational problems associated with their use including batteries and body mounted antennas. Experimental data is included to illustrate some of the principles and problems surrounding their use. The conclusion includes recommendations of various items for inclusion in a standard for body worn transmitters. A fairly extensive annotated bibliography is also provided.

16238. Richmond, J. C., **Active night vision devices,** *NILECJ-STD-0305.00,* 31 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: contrast transfer function; distortion; flare; image intensifier tubes; infrared searchlights; infrared viewers; light equivalent background; light induced background; optical gain.

An active night vision device consists of a viewer incorporating a single-stage image intensifier tube with an S-1 photocathode, that is sensitive to light at wavelengths out to about 1.1 μm, and an infrared searchlight which usually makes use of a quartz halogen lamp and an infrared filter that blocks all visible light. The standard describes test procedures for evaluating optical gain, light induced background, light equivalent background, contrast transfer function, flare and distortion of the viewer, and effective range of the searchlight, and establishes minimum levels of performance for these criteria.

16239. Richmond, J. C., **Passive, first generation night vision devices,** *NILECJ-STD-0304.00,* 25 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: contrast transfer function; flare; image intensifiers; law enforcement; light equivalent background; light induced; optical gain; night vision.

The Standard establishes test methods and performance criteria for passive, hand-held night vision devices for use in law enforcement. The viewers covered by this Standard are of the three-stage image intensifier type, that were originally developed for military use.

Test procedures and performance requirements are listed; (A) for (1) focus adjustment, (2) curvature of field, and (3) distortion of eyepiece lenses; (B) for (1) optical gain, (2) optical gain stability, (3) light equivalent background, (4) light induced background, (5) luminance of output screen, (6) luminance uniformity, (7) cathode and screen quality, (8) contrast transfer function, (9) distortion, and (10) flare of a night vision device complete with objective lens, but with the eyepiece removed; (C) for resistance to (1) vibration, (2) high and low temperature storage, (3) thermal shock, and (4) humidity of night vision device complete with both objective and eyepiece lenses; and (D) for (1) boresight adjustment, (2) click movement, and (3) resistance to mechanical shock of night vision devices intended for use as rifle sights.

16240. Bennett, L. H., Page, C. H., Swartzendruber, L. J., **Comments on units in magnetism,** (Proc. 21st Annual AIP Conf. No. 29, on Magnetism and Magnetic Materials-1975, Philadelphia, PA, Dec. 9-12, 1975), Paper in *Magnetism and Magnetic Materials-1975,* J. J. Becker, G. H. Lander, and J. J. Rhyne, Eds., 3 pages (American Institute of Physics, New York, NY, 1975).

Key words: magnetism; units.

Suggestions are given on how to express magnetic quantities in SI units.

16241. Ramsburg, R. E., Aronoff, M. J., **Calculation by digital computer of minimum station-to-station distances in the United States railroad network,** *Report No. DOT P 6300.1,* 46 pages (Department of Transportation, Washington, DC, June 1972).

Key words: railroad freight movements; short-line miling system; waybills.

This volume is the first of a series of two documents which report a package of computer programs developed by the Technical Analysis Division of the National Bureau of Standards for the computation of "short-line" distances. The "short-line" distance between two stations in a rail network is defined as the shortest route between them over which carload traffic can be moved without transfer of lading. The network treated in this

specific application was the continental United States railroad system. After its development, the package was used to "mile" the 1969 Waybill File.

Volume one outlines the background of the project, defines the general problem, describes the alternative methodologies considered, and outlines the final solution.

Volume two is both an operations manual for personnel who will annually operate the computer programs to calculate short-line distances for the Waybill File, and a programmer's manual providing technical descriptions and flow charts for each of the computer programs in the short-line "miling" package.

The programs which were developed for this project, and the partitioning technique employed, can be modified to carry out similar calculations for other large networks.

16241A. Ramsburg, R. E., Batten, D. R., Programmer level documentation of the short line mileage programs for the United States railroad network, *Report No. DOT P 6300.1*, 106 pages (Department of Transportation, Washington, DC, June 1972).

Key words: programmer's documentation; short line mileage; waybill file.

This volume is the second of a series of two documents which report a package of computer programs developed by the Technical Analysis Division of the National Bureau of Standards for the computation of "short-line" distances. The "short-line" distance between two stations in a rail network is defined as the shortest route between them over which carload traffic can be moved without transfer of lading. The network treated in this specific application was the continental United States railroad system. After its development, the package was used to "mile" the 1969 Waybill File.

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The programs which were developed for this project, and the partitioning technique employed, can be modified to carry out similar calculations for other large networks.

16242. Hougen, J. T., **Calculation of vibrational level populations in multiphoton absorption processes,** *J. Chem. Phys.* **65,** No. 3, 1035-1041 (Aug. 1, 1976).

Key words: floquet theory; laser-induced reactions; multiphoton processes; numerical calculations; relaxation phenomena; vibrational populations.

A simple procedure is described for computing steady-state excited vibrational state populations for multiphoton absorption processes in many-level systems. The procedure utilizes techniques already in the literature, i.e., expansion of the density matrix as a Fourier series in the frequency of the monochromatic radiation field, and introduction of linewidths and thermal relaxation by the addition of empirical terms to the density matrix time-development equation. Numerical computations can be carried out quickly on idealized systems, using commercially available band matrix inversion routines. A sample calculation for a 10-level, nine-photon process is presented.

16243. Wachtman, J. B., Jr., **Ceramic materials in high temperature gases: Fundamental behavior controlling lifetime in coal conversion applications,** (Proc. Ceramic Materials in High Temperature Gases on Materials Problems and Research Opportunities in Coal Conversion, Columbus, OH, Apr. 16-18, 1974), Paper in *Materials Problems and Research Opportunities in Coal Conversion* **2,** 335-343 (The Department of Metallurgical Engineering, The Ohio State University, Columbus, OH, 1974).

Key words: ceramics; coal conversion; coal gasification; corrosion; fracture; vaporization.

The degradative processes which ceramics in high temperature gases produced by coal conversion may undergo are briefly reviewed. These include purely chemical processes such as combination of liquids in cracks and subsequent corrosion. These also include chemical modification of physical processes of deterioration such as environmental effects in fracture.

16244. Bovey, F. A., Schilling, F. C., McCrackin, F. L., Wagner, H. L., **Short-chain and long-chain branching in low-density polyethylene,** *Macromolecules* **9,** No. 1, 76-80 (Jan.-Feb. 1976).

Key words: branching; limiting viscosity numbers; long-chain branching; nuclear magnetic resonance; polyethylene; short-chain branching.

The branch content of two fractions of low-density polyethylene has been examined by ^{13}C NMR (at 25 MHz) and by limiting viscosity number (intrinsic viscosity) measurements. The ^{13}C spectra, interpreted with the aid of modified Grant-Paul chemical shift rules and the spectra of model copolymers, confirm that the principal type of short branch is trifunctional *n*-butyl (5-6 per 1000 CH_2) with smaller contents of *n*-amyl (ca. 2 per 1000 CH_2) and ethyl (ca. 1 per 1000 CH_2). A resonance at (32.1_6) ppm (from TMS), corresponding to the third carbon (C-3) from the branch end, provides a measure of branches longer than *n*-amyl, but does not at present distinguish such branches, presumably formed by intramolecular "backbiting," from the truly "long" branches, containing possibly many tens or hundreds of carbons and formed by intermolecular chain transfer to other polymer chains. If it is assumed that this resonance provides in fact a direct measure of the "long" branch content, "short" branches longer than *n*-amyl being of negligible probability, the results agree well with the long branch content estimated from the intrinsic viscosities of branched and linear polyethylene via the Simm-Kilb *g* value. The long branch content thus deduced is ca. 0.8 per 1000 CH_2. For these samples, no marked dependence on molecular weight is observed for either the long- or short-branch frequencies.

16245. Davis, R. M., **National policies for information processing: Situation in the United States,** (Proc. 2d Jerusalem Conf. on Information Technology, Jerusalem, Israel, July 29-Aug. 1, 1974), Paper in *The 2d Jerusalem Conference on Information Technology: Computers for Social and Economic Development*, C. C. Gotlieb and H. Maisel, Eds., **1,** 15-27 (1974).

Key words: executive programs; information management; information processing; legislative programs; national policies; public concern.

The topic of a National Policy for Information Processing in the United States would be short-lived if it were broached as a direct question, for the answer would be "No, there is no such national policy!" However, discussions of the changing national interest in information and of emerging national concerns with information and its processing in the United States will give evidence of an increased national awareness of information processing.

Similarly, a description and status of certain legislative and executive programs in the general area of information processing

will furnish some idea of current, widely-impacting problem areas and on-going efforts to resolve them on a nation-wide or government-wide basis. Finally, public concern and involvement with information processing will be described to highlight the increasingly-intense interaction between information technology and the public.

With this broader interpretation of the topic in terms of: Changing national interest in information; emerging national concerns with information and its processing; legislative and executive programs in the general area of information processing; current, widely-impacting problem areas in information processing; and public concern and involvement with information and its processing, a perspective can be obtained of national policy in-the-making.

16246. Linden, T. A., **The use of abstract data types to simplify program modifications,** (Proc. Conf. on Data: Abstraction Definition and Structure, Salt Lake City, Utah, Mar. 22-24, 1976), *SIGPLAN Notices 11, Special Issue, Assoc. Comput. Mach.-FDT* **8,** No. 2, 12-23 (Association for Computing Machinery, New York, NY, Mar. 1976).

Key words: abstract data types; class; cluster; data abstraction; data type; module; programming methods; program modifications; type.

If a program is structured using abstract data types as the basic unit of modularity, then that program is much easier to extend or modify. This thesis is illustrated by the staged development of a program to compute prime numbers based on the sieve of Eratosthenes. This paper includes an extensive introduction to the concept of abstract data types and can be used as a tutorial survey. It includes discussions on the use of abstract data types in connection with recent approaches to data abstractions, heirarchical structure, and program design. Abstract data types are an extension and modification of the traditional concept of data type. An abstract data type defines not only a data representation for objects of the type but also the set of operations that can be performed on objects of the type. Furthermore, the abstract data type can protect the data representation from direct access by other parts of the program.

16247. Abrams, M. D., **Measuring service delivered in interactive computing,** (Proc. 2d Jerusalem Conf. on Information Technology, Jerusalem, Israel, July 29-Aug. 1, 1974), Paper in *The 2d Jerusalem Conference on Information Technology: Computers for Social and Economic Development,* C. C. Gotlieb and H. Maisel, Eds., **1,** 747-754 (1974).

Key words: computer; interactive; measurement; procurement; response; service.

This paper considers the measurement of service rendered by interactive computer systems and application of these measurements to the procurement process. Topics discussed include what to measure; response, psychological, throughput, and cost-benefit considerations; when to measure; where to measure; how to measure; measurement conditions; and data analysis. Ongoing efforts at ICST are presented as examples of the state of the art.

16248. Muehlhause, C. O., **Costs, real and perceived, examined in a risk-benefit decision framework,** (Proc. OECD Conf. on Costs, Real and Perceived, Examined in a Risk-Benefit Decision Framework, Paris, France, Aug. 1972), Paper in *Environmental Damage Costs,* pp. 282-304 (Director of Information, OECD, Paris, France, 1974).

Key words: consumer product hazard; risk-benefit.

The so-called problem of risk-benefit is analyzed with special emphasis on the case of consumer products which exhibit hazard as well as utility. The market demand is represented as a function of two independent factors: a vital one re safety, and a utilitarian one to which dollar values may be assigned. The condition for optimization of the net public benefit is examined along with its dependence on costs. The general ideas developed are extended to some more complex cases and regimes.

16249. Casella, R. C., **Possible failure of the Pomeranchuk Theorem. Shrinkage of the forward elastic peak and oscillations,** (Proc. "Ettore Majorana" School of Subnuclear Physics, Erice, Sicily, July 1-19, 1970), Paper in *Elementary Processes at High Energy,* A. Zichichi, Ed., 519-525 (Academic Press, Inc., New York, NY, 1971).

Key words: asymptotics; elastic; oscillations; Pomeranchuk; shrinkage; theorem.

Under rather general assumptions, it is shown that if the Pomeranchuk Theorem fails such that $\sigma_+(s) \to$ unequal constants, then the differential elastic cross section $d\sigma/dt$ oscillates wildly with t as well as exhibiting a $(\ln s)^2$ shrinkage of the forward peak.

16250. Muehlhause, C. O., **Risk benefit analysis,** *ASTM Stand. News* **1,** No. 2, 8-13 (Feb. 1973).

Key words: consumer product hazard; risk-benefit.

The so-called problem of risk-benefit is analyzed with special emphasis on the case of consumer products which exhibit hazard as well as utility. The market demand is represented as a function of two independent factors: a vital one re safety, and a utilitarian one to which dollar values may be assigned. The condition for optimization of the net public benefit is examined along with its dependence on costs. The general ideas developed are extended to some more complex cases and regimes.

16251. Finnegan, T. F., **Superconductivity in dc voltage metrology,** (Proc. Summer Course on the Science and Technology of Superconductivity, Georgetown University, Washington, DC, Aug. 13-26, 1971), Paper in *The Science and Technology of Superconductivity,* W. D. Gregory, W. N. Mathews, Jr., and E. A. Edelsack, Eds., **2,** 565-585 (Plenum Press, New York, NY, 1973).

Key words: ac Josephson effect; low-temperature voltage divider; superconducting tunnel junctions; voltage standard.

The simple theory of the ac Josephson effect in a tunnel junction is presented and recent work on the development and implementation of a national voltage standard based on measurements of the fundamental physical constant 2e/h is reviewed. The principle problems associated with the design and construction of conventional-type high-accuracy low-voltage dividers are treated, and the role of the cryogenic potentiometer and superconducting null detector in a Josephson-effect voltage standard is explored. Finally, a possible secondary voltage standard based on Giaever tunneling is described.

16252. Eitzen, D. G., Chwirut, D. J., **Ultrasonic reference blocks and characterized fatigue cracks,** (Proc. ARPA/AFML Review of Quantitative Nondestructive Evaluation, Thousand Oaks, CA, July 15-17, 1975), Paper in *Proceedings of the ARPA/AFML Review of Quantitative NDE, Technical Report AFML-TR-75-212,* pp. 107-127 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, Jan. 1976).

Key words: acoustic emission; aluminum; fatigue cracks; flat bottomed holes; standards; steel; titanium; transducer calibration; ultrasonic reference blocks.

Work in progress on the improvement of ASTM E127 type ultrasonic reference blocks (flat bottomed holes) and on the

development of well characterized fatigue crack is described. A data base for aluminum reference blocks has been developed by borrowing sets of field blocks and obtaining the response using 2.25, 5, and 10 MHz transducers. Steel and titanium blocks are also studied. Considerable effort has been expended in order to evaluate the contributions of metallurgical condition, physical dimensions and fabrication methods to the variability of the reference blocks. The variability due to different measurement systems and different operators was also quantified to an extent. Several possible methods of providing improved standards are suggested.

While standard defects such as cracks seem impractical to produce, it seems feasible to produce well characterized cracks. Work on characterizing fatigue cracks produced in standard ASTM E399 compact tension specimens has centered on controlling as many of the variables affecting ultrasonic response as possible. The affect of the remaining variables on ultrasonic response will be characterized. The fatigue loading program is controlled to produce nominally identical cracks. Six different techniques for measuring the physical characteristics of the cracks are being evaluated and generally show good correlation.

Techniques which have been developed for the calibration of ultrasonic and acoustic emission transducers are noted in passing.

16253. Langhoff, P. W., Corcoran, C. T., **Tchebycheff-derivative approximations to photoabsorption cross sections in atoms and ions,** *Chem. Phys. Lett.* **40,** No. 3, 367-371 (June 15, 1976).

Key words: atomic spectroscopy; photoabsorption.

Spectral moments and Tchebycheff's inequalities are employed in the construction of continuous, convergent approximations to photoabsorption and ionization cross sections in atoms and ions.

16254. Unassigned.

16255. Deslattes, R. D., Henins, A., Schoonover, R. M., Carroll, C. L., Bowman, H. A., **Avogadro constant—Corrections to an earlier report,** *Phys. Rev. Lett. Comments* **36,** No. 15, 898-900 (Apr. 12, 1976).

Key words: Avogadro constant; crystals; lattice parameter.

Corrections are required to values of silicon crystal density and lattice parameter used in our determination of N_A. The corrections are of the order of 1 ppm but taken together result in a change of the previously reported value of 0.03 ppm. A published suggestion that the lattice-parameter measurement might require a much larger correction appears unsupported.

16256. Bulos, B. R., Phelps, A. V., **Excitation of the 4.3-μm bands of CO_2 by low-energy electrons,** *Phys. Rev. A* **14,** No. 2, 615-629 (Aug. 1976).

Key words: carbon dioxide; cross section; electrons; excitation; infrared; rate coefficient.

Rate coefficients for the excitation of the 4.3-μm bands of CO_2 by low-energy electrons in CO_2 have been measured using a drift-tube technique. The CO_2 density [$(1.5 \text{ to } 7)\times 10^{17}$ molecules/cm^3] was chosen to maximize the radiation reaching the detector. Line-by-line transmission calculations were used to take into account the absorption of 4.3-μm radiation. A small fraction of the approximately 10^{-8} W of the 4.3-μm radiation produced by the approximately 10^{-7}-A electron current was incident on an InSb photovoltaic detector. The detector calibration and absorption calculations were checked by measuring the readily calculated excitation coefficients for vibrational excitation of N_2 containing a small concentration of CO_2. For pure CO_2 the number of molecules capable of emitting 4.3-μm radiation produced per cm of electron drift and per CO_2 molecule varied from 10^{-17} cm^{-2} at $E/N = 6\times 10^{-17}$ V cm^2 to 5.4×10^{-16} cm^{-2} at $E/N = 4\times 10^{-16}$ V cm^2. Here E is the electric field and N is total gas density. The excitation coefficients at lower E/N are much larger than estimated previously. A set of vibrational excitation cross sections is obtained for CO_2 which is consistent with the excitation coefficient data and with most of the published electron-beam data.

16257. Ayres, T. R., Linsky, J. L., **The Mg II *h* and *k* lines. II. Comparison with synthesized profiles and Ca II K,** *Astrophys. J.* **205,** No. 3, Part 1, 874-894 (May 1, 1976).

Key words: radiative transfer; solar chromosphere; solar photosphere; solar ultraviolet spectrum.

We compare the Mg II *h* and *k* resonance line data of Kohl and Parkinson and profiles of the Ca II K line with synthetic spectra computed using a partial redistribution formalism and several single-component solar upper photosphere and lower chromosphere models. We find that the HSRA and Vernazza *et al.* (VAL) models predict systematically lower intensities in the *h*, *k*, and K inner wings than are observed, but that models with a somewhat larger minimum temperature ($T_{min} \approx 4450$ K), such as proposed previously by Shine *et al.*, can reproduce the measured inner wing intensities and limb darkening of these resonance lines. Upper photosphere temperature distributions with $T_{min} \approx 4450$ K are also more consistent with the radiative equilibrium models of Athay (non-LTE) and Kurucz (LTE), when nonradiative energy dissipation is taken into account. We propose a "hot" T_{min} solar model, which is reasonably consistent with the empirical emission cores and wing intensities of the Ca II and Mg II resonance lines, to serve as an alternative to the class of models, such as the HSRA and VAL, based on continuum observations.

16258. Schnaus, U. E., Schroeder, J., Haus, J. W., **Subcritical viscosity anomaly in sodium silicate glasses,** *Phys. Lett.* **57A,** No. 1, 92-94 (May 17, 1976).

Key words: correlation length; Ginzburg-Landau theory; glass; inhomogeneous system; subcritical region; viscosity.

A subcritical viscosity anomaly is reported in binary mixtures of Na_2O-SiO_2. The results are discussed qualitatively in terms of inhomogeneities which are present in the system.

16259. Mann, W. B., Huchinson, J. M. R., **The standardization of iodine-129 by beta-photon coincidence counting,** *Int. J. Appl. Radiat. Isot. Tech. Notes* **27,** No. 3, 187-188 (Mar. 1976).

Key words: beta; coincidence counting; gamma; radioactivity; standardization; ^{129}I.

Sources of ^{129}I quantitatively deposited on ion exchange resin paper were calibrated by means of a simple β-γ coincidence experiment recently performed over a period of a few days at NBS.

16260. Fromhold, A. T., Jr., **Parabolic oxidation of metals in homogeneous electric fields,** *J. Phys. Chem. Solids* **33,** 95-120 (1972).

Key words: conductivity; electric field effects; insulating films; insulators; metal oxidation; metals; MOM devices; oxidation; oxidation theory; parabolic law for metal oxidation; semiconductors.

A previously proposed thin film parabolic growth law (Fromhold, 1963) is extended to include film growth due to any number of diffusing defect species of arbitrary valence, and an analysis is made of the effects of applying external electrostatic potentials during oxidation. The total electrical conductivity and the partial conductivities are markedly position-dependent in the protective

film, varying by orders of magnitude from one interface to the other. The built in electrostatic potential across the film is independent of thickness of the film and is a function of the partial conductivities of the diffusing ionic and electronic defect species. Effects of electrical shorting of the oxide film by external circuitry are analyzed. Depending on polarity, a constant applied potential can increase or decrease the rate constant but does not alter the kinetics from the parabolic form, in accordance with published experimental data. The net electrostatic potential required to stop metal oxidation is derived for the model in question. For growth by a single ionic species, the stopping potential is that electrostatic potential which gives an equal electrochemical potential at the metal-oxide and the oxide-oxygen interfaces. For growth by multiple ionic species, the stopping potential is a function of the ionic partial conductivities.

16261. Carlsten, J. L., Szöke, A., **Collisional redistribution of near-resonant scattered light in Sr vapour,** *J. Phys. B Letter to Editor* **9,** No. 9, L231-L235 (1976).

Key words: collisions; near-resonant scattering; redistribution; strontium.

Strontium vapour was irradiated by a dye laser tuned near the 460.73 nm ($^1P_1{}^0$-$^1S_0$) resonance transition. Collision-induced fluorescence at the resonance frequency and Rayleigh scattering at the laser frequency were studied as a function of detuning Δ over a range of about 30 nm (1500 cm^{-1}). The Rayleigh component was found to vary as Δ^{-2}, as expected, whereas the collision-induced fluorescence was markedly asymmetric. This experiment constitutes a direct measurement of the redistribution function.

16262. Chen, S. T., Gallagher, A., **Excitation of the Ba and Ba^+ resonance lines by electron impact on Ba atoms,** *Phys. Rev. A* **14,** No. 2, 593-601 (Aug. 1976).

Key words: barium; electron impact; excitation.

The relative optical excitation functions and polarizations of the Ba resonance line (5535 Å) and of the Ba^+ resonance lines (4554 and 4934 Å) have been measured, using crossed electron and barium-atom beams. The Ba 6^1P excitation function has been normalized to the Bethe theory in the high-energy limit, and the excitation functions of the ionic lines have been measured relative to that of the atomic resonance line. Using spontaneous-emission branching ratios for the $Ba^+(6^2P)$ levels, we have also obtained normalized cross sections for these ionizing excitation levels. From a few electron volts above threshold, the $Ba^+(6^2P)$ ionizing-excitation cross section has nearly the same energy dependence as has been reported for the total Ba^+ ionization cross section, but about 1/6 the magnitude. In particular, a broad maximum at ~22 eV, attributed to core-excited autoionizing levels, apparently contributes an equal fraction to both cross sections. This relationship holds also for the ionizing excitations versus total ionization of Sr. The cross sections for exciting the resonance levels of He, Mg, Ca, Sr, and Ba are also intercompared in reduced units and found to be strikingly similar at collision energies above ~3 times the threshold energies.

16263. Suzuki, G., Carter, C., Lieblein, J., Murphey, W. M., Perella, F. J., Smith, C. N., **Safeguards accountability analysis in a nuclear fuel processing plant,** Paper in *Safeguards Systems Analysis of Nuclear Fuel Cycles, WASH-1140 Safeguards and Nuclear Materials Management UC-15,* 46 pages (Office of Safeguards and Materials Management, U.S. Atomic Energy Commission, Washington, DC, Oct. 1, 1969).

Key words: material balance accounting; nuclear materials safeguards; process losses.

Material accounting constitutes an important, if not the principal means for suspecting and detecting diversions of Special Nuclear Material (SNM). Since the nature of SNM and the processes involved preclude precise identification of all the material through its various physical transformations within a plant, or within any part of the nuclear fuel cycle, the detection of diversions through an accounting system depends upon knowledge of the expected values and variabilities of the recorded losses under diversion-free conditions. This paper examines the variations of material unaccounted for (MUF) derived from material balance accounts, and reports on attempts to isolate the various components of MUF for a selected nuclear processing operation.

16264. Smith, J. C., **The elastic constants of a particulate-filled glassy polymer: Comparison of experimental values with theoretical predictions,** *Polym. Eng. Sci.* **16,** No. 6, 394-399 (June 1976).

Key words: bulk modulus; composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; shear modulus; Young's modulus.

Calculation of the elastic constants of a particulate composite material in terms of the elastic constants of the filler and the matrix is discussed. The theories of Kerner or Hashin and Shtrikman, the equivalent theories of Budiansky and Hill, and a generalized van der Poel type theory are presented and discussed. Data from several sources are compared with the predictions of these theories. The van der Poel theory provides the best agreement and gives good values for volume fractions of filler up to 0.35.

16265. Calvano, N. J., Dobbyn, R. C., **Riot helmets,** *NILECJ-STD-0104.00,* 15 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1974).

Key words: helmets; impact attenuation; penetration; retention system strength; riot; visual clearance.

This standard establishes performance requirements and methods of test for helmets used to protect the wearer during civil disturbances, riots or other situations that pose a threat of injury from blows to the head. The test methods described measure the ability of the helmet to attenuate impact, resist penetration and provide sufficient peripheral visual clearance and test the static strength of the helmet's retention system. It is based on ANSI standard Z90.1-1971.

16266. Fey, R. L., **Automatic vehicle location techniques for law enforcement use,** *LESP-RPT-0205.00,* 27 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1974).

Key words: automatic vehicle locator; car locators; law enforcement.

Automatic vehicle location systems employing communications techniques are presently under development by several companies. This report discusses such systems with respect to law enforcement applications. It presents the principles upon which the various automatic location techniques are based, summarizes their important characteristics, and compares them as candidates for law enforcement use. This report discusses techniques, available system performance, and the related aspect of frequency spectrum requirements for these systems. It also mentions areas where more operational information is needed before systems for law enforcement operations can be clearly defined.

16267. Robertson, B., Baumgarten, G. P., **Evaluation of automotive fuel flowmeters,** (Proc. Project Coordination Meeting of the Automotive Energy Efficiency Program, Cambridge, MA, Nov. 4-6, 1975), *Report No. DOT-TSC-OST-76-1*, 20 pages (Available from the National Technical Information Service, Springfield, VA 22161, June 1976).

Key words: automotive environment; calibration; low flow rates.

A description is given of laboratory apparatus and procedures for evaluating gasoline flowmeters under conditions simulating the automotive environment. Preliminary results are reported on tests of three commercially available automotive fuel flowmeters.

16268. Eicke, W. G., Jr., **The volt, yesterday, today and tomorrow,** (Proc. PSA Int. Conf., Chicago, IL, Oct. 4-7, 1971), *ISA Reprint 71-703*, pp. 1-7 (Oct. 1971).

Key words: electrical standards; standard cells; U.S. legal volt; volt; voltage measurement.

Of all the electrical quantities used today, the unit of voltage is probably the most difficult to maintain, disseminate and use properly. This paper briefly discusses the history of the volt to 1967. Work at NBS after 1967 is described. Developments are reported in four basic areas: 1) The application of statistical design and digital computers to obtain additional information about the measurement process, 2) improvements in the equipment for making standard cell measurements, 3) improvement in the temperature control of standard cells, and 4) improved techniques for disseminating the volt. To further improve the volt, the progress for maintaining surveillance over the unit by means of the gyromagnetic ratio of the proton and the Josephson effect are discussed.

16269. Cook, R. K., **Acoustic emissions—Researchers in Japan,** *Sci. Bull.* **1,** No. 1, 17 pages (June-Sept. 1976).

Key words: acoustic emission; acoustics; flaw detection; nondestructive inspection.

While in Japan in the summer of 1975, I undertook an investigation, at the request of the Office of Naval Research, into the current state of Japanese research techniques and technological applications of acoustic emissions (AE). The investigation was done mainly by means of visits to laboratories and conferences with physicists and engineers working on AE in the Tokyo area. The visits and conferences were held during the week of 1-5 September 1975. All of the conferences were on an unclassified basis. In addition, various published papers describing Japanese researches on AE have been studied. Most of these are in the *List of Publications* of the Report. The list includes about 40 publications from Japanese laboratories working on acoustic emissions.

16270. Fuller, E. G., Hayward, E., Eds., **Photonuclear reactions,** *Book—Benchmark Papers in Nuclear Physics* **2,** 426 pages (Dowden, Hutchinson & Ross, Inc., Stroudsburg, PA, 1976).

Key words: history; photonuclear experiments; photonuclear interaction; photonuclear reactions; photonuclear theory; reprint collection.

A collection of 43 reprints of research papers which have made a significant impact on the development of the photonuclear physics field are presented. Comments associated with each paper place it into the context of the historical development of the field, and indicate the particular contributions each paper has made to the development of an understanding of the nuclear photoeffect and nuclear structure. The papers are all concerned with classical photonuclear physics, the interaction of real photons having energies less than 150 MeV with nuclei. The field of inelastic electron scattering is not treated.

16271. Panek, R. J., Savage, B. D., **Ultraviolet photometry from the orbiting astronomical observatory. XXIII. The resonance lines of triply ionized carbon and silicon in the spectra of hot stars,** *Astrophys. J.* **206,** No. 1, 167-181 (May 15, 1976).

Key words: absorption; B-stars; C IV; O-stars; Si IV; spectra; stellar; ultraviolet.

Quantitative measurements of the absorption strength of the Si IV (1400 Å) and C IV (1550 Å) resonance doublets have been made from OAO-2 far-ultraviolet spectra of 118 O- and B-type stars. These lines are generally very strong and a useful measure of their strength can be made even though the OAO-2 scans have relatively low spectral resolution (FWHM = 12 Å). However, variable amounts of line blending limit the accuracy of the results to approximately ± 1 to 2 Å in the equivalent width. For dwarf stars the strength of both features correlates well with spectral type or temperature. The Si IV doublet peaks in strength near spectral type B1 with a total equivalent width of about 5 Å in agreement with the theoretical non-LTE (NLTE) plane-parallel static models of Kamp. The C IV doublet in dwarfs rapidly increases in strength from B2 to B0 and attains an equivalent width of about 5 Å at spectral type O9. For both doublets we note a large increase in the absorption equivalent width with luminosity classification, the increase amounting to a factor of 2 to 3 between dwarfs and supergiants. In the luminous O stars we also note a change in the line profile to the P Cygni type. In the case of the Si IV line for stars cooler than spectral type B0.5 the observed luminosity effect is roughly consistent with the predictions of static NLTE models. However, for the O stars the static models predict a *decrease* in equivalent width with increasing luminosity. The differences between theory and observation are associated with the effects of mass outflow.

The observations include a number of B stars with peculiar visual spectra. With the exception of θ Car, which exhibits an abnormally weak C IV line, the various peculiar stars observed appear to have normal Si IV and C IV line strengths.

For a group of rapidly rotating stars the C IV line appears marginally stronger than expected on the basis of MK classification, while Si IV appears normal. In the case of the Be shell star, γ Cas, we have noted a factor of 2 increase in the strength of Si IV and C IV over a time scale of months.

With the exception of ξ^1 CMa and β Cep, the Si IV and Ce IV lines in a group of 11 β Cephei variables appear to have strengths consistent with their MK classification.

A number of repeated observations of bright early-type stars were searched for absorption line variability on time scales ranging from minutes to years. With only a few exceptions no variability was found. The sample included a number of luminous O supergiants, suggesting that the mass loss from these objects occurs as a steady process.

16272. Mihalas, D., Kunasz, P. B., Hummer, D. G., **Solution of the comoving-frame equation of transfer in spherically symmetric flows. III. Effect of aberration and advection terms,** *Astrophys. J.* **206,** No. 2, 515-524 (June 1, 1976).

Key words: radiative transfer; relativistic effects; spectral line formation; stellar atmospheres.

We investigate the importance of the advection and aberration terms, which are of order V/c, in the comoving-frame transfer equation in spherical geometry. Characteristic trajectories are found which reduce the spatial derivatives to a perfect differential, and a generalization of the numerical procedure

developed in the earlier papers of this series that permits the integration of the transfer equation on these characteristics is presented. For cases in which $V/c \ll 1$, a perturbation solution is developed which reduces the problem to that solved in the first paper in this series. For velocities of the form $V(r) \sim r^n (n = 0, 1, 2)$, it is shown that the magnitude of the effects arising from the advection and aberration terms is about $5V/c$ relative to the solution with these terms omitted. In stellar winds $V/c \lesssim 0.01$; hence we conclude that aberration and advection terms may safely be ignored, and that consideration of the Doppler-shift term alone is adequate in the computation of spectra from such expanding atmospheres.

16273. Swartzendruber, L. J., Evans, B. J., **Nuclear gamma ray resonance observation of the activation process in Raney iron and Urushibara iron catalysts,** *J. Catal.* **43,** 207-219 (1976).

Key words: catalysis; Mössbauer effect; Raney-iron-activation.

The phases that form when Raney iron and Urushibara iron catalysts are activated have been studied utilizing ^{57}Fe nuclear gamma ray resonance. For Raney iron catalysts four phases are observed in the activated catalyst; residual aluminum-depleted Raney alloy, $Fe(OH)_2$, α-Fe and Fe_3O_4. The relative proportions of phases present is a sensitive function of leaching temperature and time. For Raney iron catalysts, and for Urushibara iron catalysts prepared using aluminum, no alloying of aluminum into the activated phases is observable. For Urushibara iron catalysts prepared using zinc, there is considerable alloying of iron and zinc. Evidence is presented to show that when the catalyst is generated at low temperatures $Fe(OH)_2$ is a precursor phase for metallic Fe in Raney Iron. A similar situation seems to exist for the Urushibara catalyst prepared using aluminum. The alloying behavior of the iron catalysts can be understood on the basis of the nature of the intermediate phase. The large amounts of Fe_3O_4 present in Raney iron prepared at elevated temperatures raises some questions concerning the catalytically active phases in such materials.

16274. Peterlin, A., **Crystallization from a strained melt or solution,** *Polym. Eng. Sci.* **16,** No. 3, 126-137 (Mar. 1976).

Key words: crystallization; cylindrite; drawing of swollen polymer solid; epitaxial overgrowth; extrusion; hard elastomer; nucleation; oriented melt; rheological unites; row nucleus; shishkebab; sonicated solution; spinning; stirred solution.

The elongation and orientation of randomly coiled macromolecules in a strained melt or solution reduces their entropy and thus increases the crystallization or melting temperature of the ideal lattice. At any given temperature of the experiment this enhances nucleation and crystal growth rate. As a rule, linear primary nuclei are formed. They contain more or less extended chains. The existence of row nuclei reduces the local gradient in the liquid to such an extent that further crystallization proceeds by epitaxial overgrowth of folded chain lamellae. Densely packed cylindrites are formed with the ribbon-like lamellae radiating from the central row nucleus. The irregular shish-kebab structure observed in stirred or sonicated solutions seems to be formed by subsequent axial deformation of cylindrites in the flow field. It displaces the lamellae irregularly and thus produces a great many microfibrillar elements parallel to the original row nuclei. The almost completely extended chains in the shish yield a high elastic modulus and tensile strength for axial loading. The shish-kebab morphology in fibers as spun does not affect to a great extent the mechanical properties obtainable by subsequent drawing. The lamellae are transformed into microfibrils in very much the same manner as in spherulitic samples. But the highly regular orientation of lamellae seems to result in a more uniform drawing and hence a stronger fiber. In an extremely high temperature and pressure gradient, the melt extrusion produces hard elastomers where the lamellae of the cylindrites seem to be locally stapled. Upon application of tensile load in the extrusion direction, the intervening sections bend like beams, thus forming thin holes extending in the direction perpendicular to the load. The holes enormously enhance the permeability for gases and liquids. The elastic bending of lamellae yields the high recoverable strain and low tensile modulus.

16275. Phillips, J. C., Mattamal, M. M., **Correlation of liquid heat capacities for carboxylic esters,** *J. J. Chem. Eng. Data* **21,** No. 2, 228-232 (Apr. 1976).

Key words: correlation; esters; heat capacity; oligomers; sebacates; triglycerides.

Liquid heat capacity data of carboxylic esters (including a sebacate series, triglyceride series, and oligomer series), covering a temperature range from 20 to about 180 °C and a molecular weight range from 116 to 939, were determined with a differential scanning calorimeter. The data, together with published heat capacity values, were reduced to a temperature independent correlation. The results suggest an approximate additivity in carboxyl content and a lack of dependence on structural type (e.g., linear, branched, or oligomeric).

16276. Unassigned.

16277. Mopsik, F. I., Broadhurst, M. G., **Molecular dipole electrets,** *J. Appl. Phys.* **46,** No. 10, 4204-4208 (Oct. 1975).

Key words: dipoles; electret; glass; piezoelectric; polarization; polyvinyl chloride; pyroelectric.

The total polarization due to molecular dipoles in a glassy electret is computed using an Onsager cavity approach. From this result, all the possible contributions to the piezoelectric and pyroelectric coefficients are considered. It is shown that there are major contributions from the variation in dielectric constant and, for pyroelectricity, from thermal motion. These results account well for experimental data for polyvinyl chloride.

16278. Penn, R. W., Kearsley, E. A., **The scaling law for finite torsion of elastic cylinders,** *Trans. Soc. Rheol.* **20,** No. 2, 227-238 (1976).

Key words: elasticity; finite torsion; natural rubber; scaling law; simple materials assumption.

The torque and forces normal to the end surfaces of cylinders of natural rubber were measured as a function of the angle of twist. The measurements were repeated on small cylinders cut from the larger cylinders to insure that the tests were on identical material. Plots of reduced torque and of reduced normal force versus reduced twist for the different sized cylinders coincide to within 1 percent. This result supports the simple material assumption of the classical theory of finite elastic deformations. An interesting instability was observed, and derivatives of the strain energy function were calculated.

16279. Fanconi, B., Crissman, J., **Influence of methyl group branches on the longitudinal acoustical mode frequencies in alkanes and polyethylene,** *J. Polym. Sci. Polym. Lett. Ed.* **13,** 421-426 (1975).

Key words: alkanes; longitudinal acoustical mode; methyl group branches; polyethylene; Raman spectroscopy.

The Raman-active longitudinal modes (LAM) of crystalline n-alkanes have been extensively studied. The frequency-chain length relationship found for the n-alkanes has been recently

used to deduce the length of the all-trans chain segments in polyethylene single crystals and to determine the paraffinic chain lengths and conformations in phospholipids. The use of LAM frequencies of n-alkanes in this manner neglects the effects of interchain interactions, terminal chain groups, and conformational or mass defects.

16280. Horowitz, E., **Transfer of measurement methodology to industry,** *J. Assoc. Eng. Archit. Isr.* **35,** 21-41 (May 1976).

Key words: benefits, industry-society; materials research; measurements-standards; NBS-industry; transfer.

The National Bureau of Standards (NBS) is engaged in a variety of measurement and standards activities, many of which are applicable to the solution of scientific and technological problems in industry and society. This paper discusses some of the innovations and accomplishments resulting from the materials programs in the NBS Institute for Materials Research and traces the work from the laboratory phase to the transfer and utilization of measurement technology and standards in industry. Also included is a brief discussion of the NBS Experimental Technology Incentives Program (ETIP) which is concerned with stimulating the implementation of innovative policies in the area of science and technology.

16281. MacDonald, R. A., Tsai, D. H., **Molecular dynamical calculations of the thermal diffusivity of a perfect lattice,** (Proc. 14th Int. Conf. on Thermal Conductivity, Storrs, CT, June 2-4, 1975), Paper in *Proceedings of the 14th International Conference on Thermal Conductivity*, P. G. Klemens and T. K. Chu, Eds., pp. 145-152 (Plenum Press, New York, NY, 1976).

Key words: continuum theory of diffusion; density; kinetic temperature; molecular dynamics; numerical error; perfect lattice; thermal conductivity; thermal diffusivity; thermoelastic coupling.

We have used the method of molecular dynamics to make a detailed study of thermal diffusivity in a perfect monatomic lattice. The interatomic potential is that appropriate for iron. We limit the atomic motions to two dimensions in order to shorten the computation. We maintain one end of the lattice at a given kinetic temperature and obtain the temperature profile in the lattice as a function of time. The total energy added to the system is recorded. We fit diffusive curves to the temperature profiles and thus obtain the thermal diffusivity of the lattice. Its value is 4×10^{-6} m^2 sec^{-1} at a mean lattice temperature of 75K.

16282. Bucaro, J. A., Simmons, J. H., **Rayleigh wave study of surface diffusion and stress relaxation in glass,** *J. Non-Cryst. Solids* **14,** 225-241 (1974).

Key words: glass; glass strengthening; ion exchange; Rayleigh waves; surface waves.

Surface wave propagation on ion-exchanged glass surfaces has been systematically studied. The glass system was an alkali-alumino silicate glass, and the ion-exchange involved the replacement of lithium ions by sodium ions. Accurate velocity measurements were carried out on systems ion-exchanged for various times and at various temperatures. The effects of density and modulus changes on the velocity have been separated. Stress build-up and relaxation have been observed which correlate well with shear viscosity measurements. In addition, the diffusion coefficient for the $Na^+ \rightleftarrows Li^+$ exchange has been determined at a variety of temperatures.

16283. DiMarzio, E. A., **Validity of the Ehrenfest relation for a system with more than one order parameter,** *J. Appl. Phys.* **45,** No. 10, 4143-4145 (Oct. 1974).

Key words: Ehrenfest relation; glassy state; order-parameters; polymer thermodynamics.

The relation $\Delta C_p \Delta\kappa = TV(\Delta\alpha)^2$ is shown to be obeyed under the same assumptions that Davies and Jones used to derive the weaker condition $\Delta C_p \Delta\kappa \geq TV(\Delta\alpha)^2$. This means that if a material is found experimentally not to obey the above equality, then it is not describable by an order-parameter theory. A prescription is given which allows one to determine within the context of order-parameter theory whether the glass transition of a given material is basically thermodynamic or kinetic in origin.

16284. Broadhurst, M. G., Harris, W. P., Mopsik, F. I., Malmberg, C. G., **Piezoelectricity, pyroelectricity and electrostriction in polymers,** *Polym. Prepr.* **14,** No. 2, 820-829 (Aug. 1973).

Key words: electret; piezoelectricity; polarization electrostriction; polymer; pyroelectricity.

Piezoelectricity in naturally-occurring biological and polarized synthetic polymers is becoming increasingly recognized as an important phenomenon. This paper traces the history of piezoelectricity in electrets and gives a simple physical basis for the effect. Measurement techniques are described and piezo- and pyroelectric data for polymers are presented and compared to data for common nonpolymeric materials.

16285. Taggart, H., Nelson, R. E., Scott, W., Jr., Shafer, J., Tary, J., Workman, J., Treado, M. J., **Personal/portable FM transmitters,** *NILECJ-STD-0203.00*, 22 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1974).

Key words: audiofrequency modulation; communications; electromagnetic compatibility; law enforcement; personal transmitter; portable transmitter; radio frequency carrier; transmitter.

The purpose of this standard is to establish performance requirements and the test methods needed to evaluate these requirements for frequency modulated personal/portable transmitters used by law enforcement agencies. Sixteen transmitter characteristics are included. Also described are a radiation test site, standard duty cycle and the characteristics of required test equipment.

16286. Treado, M. J., Taggart, H. E., Nelson, E., Scott, W. W., Shafer, J. F., Tary, J. J., **Fixed and base station FM transmitters,** *NILECJ-STD-0201.00*, 20 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1974).

Key words: base station transmitter; communications; fixed transmitter; FM transmitter; law enforcement; transmitter.

The purpose of this standard is to establish performance requirements and methods of test for FM fixed and base station transmitters used by law enforcement agencies. It should be used with transmitters which either do not have subsystems such as selective signaling or in which such subsystems are disabled or bypassed. This standard is applicable to transmitters licensed to operate in the 25-50 MHz, 150-174 MHz, and 400-512 MHz bands, and includes the performance requirements and test methods for 16 different transmitter characteristics.

16287. Calvano, N. J., Dobbyn, R. C., **Crash helmets,** *NILECJ-STD-0105.00*, 13 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: crash; helmet; impact attenuation; penetration; retention system strength; visual clearance.

This standard establishes performance requirements and methods of test for helmets used to protect the wearer while a driver or passenger of a surface vehicle. The test methods described measure the ability of the helmet to attenuate impact, resist penetration and provide sufficient peripheral visual clearance and test the static strength of the helmets' retention system. It is based on ANSI Standard Z90.1-1971.

16288. Hartman, A. W., **Proposed image space scanner with reduced off-axis defocusing,** *Opt. Eng.* **15,** No. 3, 262-264 (May-June 1976).

Key words: defocusing; image space off-axis; line scanner; optical.

An optical line scanner with a scanning mirror between the optics and the image can be modified to produce more than twice the field of view of a conventional image space scanner, without increase in off-axis defocusing. The proposed approach consists of moving the rotation center of the scanning mirror away from a point on the optical axis to a specified point off-axis.

Two examples of such a scanner modification are analyzed: a flat-field microscope scanner with high resolution and a curved-field night-viewing scanner with high optical speed.

16289. Crissman, J. M., **On the transition from paraffinic to polymeric behavior: Mechanical properties,** *J. Polym. Sci. Part A-2,* **13,** 1407-1416 (1975).

Key words: chain folds; differential scanning calorimetry; linear polyethylene fractions; low angle x ray; mechanical relaxation; tetranonacontane.

An attempt has been made to determine what influence chain folds may have on the α and γ mechanical loss peaks in linear polyethylene. In so doing, one long-chain *n*-paraffin ($C_{94}H_{190}$) and two low molecular weight polyethylene fractions have been examined with mechanical relaxation, differential scanning calorimetry (DSC), and low-angle x-ray diffraction techniques. The data suggest that chain folds play a prominent role in both the α and γ processes but that other factors such as polydispersity and/or branching are also important.

16290. DiMarzio, E. A., Bishop, M., **Connection between the macroscopic electric and mechanical susceptibilities,** *J. Chem. Phys.* **60,** No. 10, 3802-3811 (May 15, 1974).

Key words: Cole-Cole plots; dielectric constants of polymers; dielectrics; electric dispersion; permeability of polymers.

The following relationship is derived between the dielectric permittivity $\epsilon(\omega)$ and the complex shear viscosity $\eta(\omega)$: $[\epsilon(\omega)-\epsilon_\infty]/(\epsilon_0-\epsilon_\infty)=[1-i\omega\eta(\omega)K]^{-1}$. This equation is derived from both a generalization of Debye's treatment and from the Kubo formalism. The model consists of dipoles imbedded in rigid beads that are in turn imbedded in the viscous medium. A frequency dependent $\eta(\omega)$ implies nonexponential decay of the electric dipoles and results in skewed-arc behavior in the Cole-Cole plots except when $\eta(\omega)$ is represented by a single Maxwell element or by a single Voigt element. Consistency with the requirements of causality and reality is displayed. Experimental $\epsilon(\omega)$ are predicted reasonably accurately by use of experimental $\eta(\omega)$ and the above equation.

16291. Edelman, S., **Piezoelectric polymer transducers,** *Proc. Workshop on Sonar Transducer Materials, Naval Research Laboratory, Washington, DC, Nov. 13-14, 1975,* pp. 269-282 (Naval Research Laboratory, Washington, DC, Feb. 1976).

Key words: flexibility; hydrophone; impedance match; low-cost transducers; piezoelectric polymers.

Polymers with significant piezoelectric activity have been developed. This material can be used to measure many forms of dynamic stress and vibration. Piezoelectric polymers can be formed in size and shape to suit a particular application and they can be fastened to curved, twisted, or compliant surfaces.

A typical piezoelectric polymer is compared with a typical piezoelectric ceramic for underwater use. A new polymer hydrophone is described whose sensitivity in the region below 1 kHz is comparable to that of conventional hydrophones.

16292. Tighe, N. J., Swann, P. R., **Magnetite lamellae in reduced hematites,** Chapter 4.3 in *Electron Microscopy in Mineralogy,* H. R. Wenk, et al., Eds., pp. 209-213 (Springer-Verlag Berlin Heidelberg, Germany, 1976).

Key words: electron microscopy; Fe_2O_3; Fe_3O_4; high-voltage electron microscopy; *in situ* hematite; magnetite.

Microstructural changes that occur during gaseous reduction of hematite (Fe_2O_3) were studied by light and electron microscopy. Reduction experiments carried out in a high-voltage electron microscope and in a controlled atmosphere furnace showed that at T = 1000 °C magnetite nucleates and grows with the $(111)_m \| (0001)_h$ habit. Lenticular magnetite plates grow by a martensitic mechanism.

16293. Arthur, M. G., Saulsbery, L. F., Scott, W. W., Jr., Shafer, J. F., **Mobile FM receivers,** *NILECJ-STD-0207.00,* 18 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: FM receivers; law enforcement equipment; minimum performance requirements; NILECJ Standard; receiver definitions; receiver measurement techniques.

This document is a voluntary performance standard that establishes minimum performance requirements and methods of test for Mobile FM Receivers used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance in Mobile FM Receivers.

16294. Jickling, R. M., **RF coaxial cable assemblies for mobile transceivers,** *NILECJ-STD-0212.00,* 9 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: cable assembly; coaxial cable; insertion loss; mobile antenna; mobile transceiver; transmission.

This standard specifies the connector plug at the mobile transceiver for an rf coaxial cable lead-in from a mobile antenna. Four performance requirements are listed, with detailed test methods for measuring characteristics such as standing wave ratio and insertion loss.

16295. Calvano, N. J., Dobbyn, R. C., **Ballistic helmets,** *NILECJ-STD-0106.00,* 13 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: armor; ballistic helmet; ballistic impact; ballistic penetration; bulletproof helmet.

NILECJ-STD-0106.00, Ballistic Helmets, is a law enforcement equipment standard developed by the Law Enforcement

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Standards Laboratory. It establishes minimum performance requirements and methods of test for helmets intended to protect the head against gunfire. Standards are established for helmets intended to provide two levels of protection: helmets protective against caliber .357 Magnum revolver fire, and helmets protective against caliber .38 Special and .22 long rifle high velocity handgun fire.

16296. Jesch, R. L., Scott, W. W., Treado, M. J., **Batteries for personal/portable transceivers,** *NILECJ-STD-0211.00,* 14 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: battery performance standard; law enforcement communications, Law Enforcement Standards Laboratory; personal/portable transceivers; primary battery; secondary battery; transceiver.

This document is a voluntary performance standard for batteries used in personal/portable transceivers. It establishes minimum performance requirements and methods of test for primary and secondary batteries, and is intended to assist law enforcement agencies in the selection and procurement of these batteries.

16297. Arthur, M. G., Saulsbery, L. F., Scott, W. W., Jr., Shafer, J. F., **Personal/portable FM receivers,** *NILECJ-STD-0208.00,* 18 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1975).

Key words: FM receivers; law enforcement equipment; minimum performance requirements; NILECJ Standard; receiver definitions; receiver measurement techniques.

This document is a voluntary performance standard that establishes minimum performance requirements and methods of test for personal/portable FM receivers used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance in personal/portable FM receivers.

16298. Teague, M. R., Lambropoulos, P., Goodmanson, D., Norcross, D. W., **Theory of two-photon ionization of cesium,** *Phys. Rev. A* **14,** No. 3, 1057-1064 (Sept. 1976).

Key words: cesium; multiphoton processes; photoionization.

We present a systematic theoretical analysis of two-photon ionization of cesium in the perturbation-theory regime. Matrix elements from diverse sources, such as quantum-defect theory and model potentials, as well as from experimental oscillator strengths, have been used in the calculation. The results are discussed in the context of recent measurements. In addition to total generalized cross sections (gcs) for linearly polarized light, ratios of gcs for linear to circular polarization, as well as photoelectron spin polarization, have been calculated. The various sets of matrix elements give results which are consistent, given variations that should be expected from the diversity of the sources. The disagreement with experiment, however, persists.

16299. Cooper, J. W., **Inner shell ionization as a single electron process,** (Proc. Int. Conf. on Inner Shell Ionization Phenomena and Future Applications, Atlanta, GA, Apr. 17-22, 1972), Paper in *Proceedings of the International Conference on Inner Shell Ionization Phenomena and Future Applications,* R. W. Fink, S. T. Manson, J. M. Palms, and P. V. Rao, Eds., CONF-720404, **2,** 807-815 (USAEC Technical Information Center, Oak Ridge, TN, Jan. 1973).

Key words: charged particle excitation; inner shells; ionization; photoionization.

Excitation ionization of inner shell electrons by photons, protons, electrons or heavy charged particles can be viewed within a common theoretical framework provided the interaction of the incident particle with the system being bombarded is sufficiently weak. Within this approximation the ionization process depends only on the energy and momentum transferred to the ionized system and may be characterized by a "Bethe Surface" in these variables. Quantitative calculations of specific processes and interpretation of experimental data often considers ionizations as a single electron (two-body) process. The basic theory of inner shell ionization treated as a single electron process will be reviewed briefly with emphasis on its range of validity and the relationship between information obtained via excitation by different incident particles.

16300. Davis, R. M., **Preventive technology: A cure for scientific ills,** *Science* **188,** No. 4185, 213 (Apr. 1975).

Key words: preventive technology; scientific ills; society and science; technology and civilization.

Preventive Technology: A Cure for Scientific Ills is an editorial dealing with scientific advancement and hopes that preventive technology can prohibit further societal side effects. Scientific discoveries are often linked with the harm that they may cause humanity rather than the good that they do (e.g., computer science is coupled to an undesirable "data bank;" and the development of synthetic plastics is linked with environmental pollution).

Prevention of scientific ills in the past and even today has taken place after the fact. It is important to recognize that science has been the primary cause of beneficial change throughout man's history. Preventive technology needs to be recognized as a scientific specialty. It must be practiced as part of every aspect of science. It will make possible both more science and more public peace of mind. Delay in setting up Preventive Technology may cause ill for both science and for future beneficial changes for society.

16301. Berger, H., **Nondestructive measurements: How good are they?,** *Mater. Eval.* **XXXIV,** No. 1, 18A-20A, 22A, 24A, 33A-34A (Jan. 1976).

Key words: accuracy; conservation; measurements; nondestructive evaluation; productivity; reliability; reproducibility; safety.

Increasing demands are being made on nondestructive evaluation (NDE) as a result of needs for safety, conservation, and productivity. This makes it all the more imperative that NDE measurements be made in a reliable, reproducible manner. The capabilities of NDE measurements are considered from the points of view of elements of the system and the measurement system as a whole. In each case, unacceptable variations in measurement accuracy, reliability, and reproducibility are identified. The NDE measurement situation is compared to measurements being made in clinical chemistry, where an improved measurement capability was brought about through the efforts of the professionals in that field, and the development of standard reference materials and measurement methods of known accuracy. The NDE community is called upon to take similar steps and contribute to the needs for improved NDE measurements and standards.

16302. Franklin, A. D., **Electrochemical growth of crystals from electrolyte solutions,** *J. Cryst. Growth* **34,** 245-247 (1976).

Key words: calcium hydroxide; crystal growth; crystals, electrochemical; electrolysis; solution.

An electrochemical crystal-growth technique is described in which an electrolyte reaction involving one ion in the desired crystal is used to create a concentration gradient in that ion across the cell. Nutrient material held near the consuming electrode is dissolved, and crystal growth near the producing electrode occurs at a rate which can be controlled by the current through the cell. The technique has been demonstrated with the growth of $Ca(OH)_2$ crystals from aqueous solutions of $CaCl_2$ plus KCl.

16303. Arthur, M. G., Saulsbery, L. F., Scott, W. W., Jr., Shafer, J. F., **Fixed and base station FM receivers,** *NILECJ-STD-0206.00*, 17 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Sept. 1975).

Key words: FM receivers; law enforcement equipment; minimum performance requirements; NILECJ Standard; receiver definitions; receiver measurement techniques.

This document is a voluntary performance standard that establishes minimum performance requirements and methods of test for fixed and base station FM receivers used by law enforcement agencies. This standard specifies the test conditions, the test equipment needed, the test methods, and the minimum performance requirements necessary for satisfactory performance in fixed and base station FM receivers.

16304. Fanconi, B., Finegold, L., **Vibrational states of the biopolymer polyglycine II: Theory and experiment,** *Science* **190,** 458-460 (Oct. 31, 1975).

Key words: heat capacity; lattice dynamics; low temperature, polyglycine; polypeptides; vibrational states.

The density of vibrational states, and hence the heat capacity, has been calculated for the parallel-chain hexagonal lattice of 3_1 helical polyglycine. The agreement with experimental results in the temperature range from 1 to 20 K, including an anomaly near 8 K, is the best obtained thus far for homopolypeptides.

16305. Dobbyn, R. C., Bruchey, W. J., Jr., Shubin, L. D., **An evaluation of police handgun ammunition: Summary report,** *LESP-RPT-0101.01*, 21 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1975).

Key words: bullets; cartridges; handgun ammunition; law enforcement; relative incapacitation index; relative stopping power.

This report summarizes the results of a laboratory study of handgun ammunition presently being marketed to law enforcement agencies. Three basic terminal effects of the ammunition have been examined: their relative incapacitation potential for human targets, their ricochet behavior and their material penetration characteristics. The focus has been on commercially available handgun ammunition in the caliber range 9 mm (.355 in) to .45. The test methods and evaluation techniques are, however, applicable to other penetrating projectiles.

16306. Lawn, B. R., Swain, M. V., Phillips, K., **On the mode of chipping fracture in brittle solids,** *J. Mater. Sci. Lett.* **10,** 1236-1239 (1975).

Key words: brittle solids; chipping; fracture; indentation; residual stress; stress analysis.

A description is given of the mode of chipping fracture observed in highly brittle solids. It is pointed out that residual stresses about indentation deformation centers play a vital role. The implications of this mode in a number of mechanical phenomena are discussed.

16307. Brown, W. E., Chow, L. C., **Chemical properties of bone mineral,** *Ann. Rev. Mater. Sci.* **6,** 213-236 (Aug. 1976).

Key words: amorphous calcium phosphate; bone mineral; fluorapatite; hydroxyapatite; morphology; nonstoichiometry; octacalcium phosphate; solubility; surface.

The literature on the chemical properties of bone mineral is reviewed. As a basis for understanding the properties of these extremely fine crystallites, reference is made first to the ideal compounds and then to the morphological, compositional, and structural modifications that bone mineral is known or implied to have. The structure of apatite is considered the most suitable prototype for bone crystallites; however, the "apatitic layer" in the crystal of octacalcium phosphate is almost identical in structure to hydroxyapatite. This close structural relationship has many implications relative to the chemistry of bone mineral. "Amorphous calcium phosphate," which has been suggested as a possible component of bone, is assessed. The properties of the so-called "amorphous" material in bone are unlikely to be closely similar to those of synthetic amorphous calcium phosphates. A theoretical basis for solubility of bone is described and its variable solubility is discussed. Because of the smallness of bone crystallites, the surface properties of bone mineral are of great importance. Both the lattice and the surface of the crystallite play important roles in processes involving the dissolution or formation of bone mineral.

16308. Horowitz, E., **Metallo-organic systems with high thermal stability,** Paper 7 in *Advances in Chemistry Series*, R. F. Gould, Ed., No. 85, pp. 82-94 (1968).

Key words: coordination polymers; role of metal and ligand; thermal stability.

When 8-hydroxyquinoline and derivatives of bis(8-hydroxyquinoline) react with metal ions, coordination complexes and polymers are formed, respectively, which exhibit improved thermal stability. This paper reviews the reaction of first-row transition metal ions with such ligands and their effect on the stabilization of these organic molecules. For the polymers containing divalent Mn, Co, Ni, Cu, or Zn the decomposition temperature is related to the periodic properties of the metal as well as the composition of the ligand to which the metal is coordinated. Trivalent chromium produces a crosslinked polymer when it reacts with bis(8-hydroxy-5-quinolyl)methane, and the thermogram for this polymer is also reported.

16309. Chang, S. S., **Low temperature thermal behavior of glassy polymers,** (Proc. ACS Coatings and Plastics 170th Meeting, Chicago, IL, Aug. 25-29, 1975), Paper in *Coatings and Plastics Preprints*, R. F. Wint, Ed., **35,** No. 2, 364-369 (American Chemical Society, Washington, DC, 1975).

Key words: glassy state; glass transition; heat capacity; polymer; specific heat; strain energy; supercooled liquid; thermal relaxation.

A brief review of the thermal behavior of glassy polymers from cryogenic temperatures to the supercooled liquid state will be presented. Results from this and other laboratories will be used to illustrate the following topics of discussion. Some of the recent results from this laboratory were obtained by means of a fully automated adiabatic calorimetric measurement system. The main instrument in the system is a computer-controlled self-balancing potentiometer. Above 25 K, the precision in the heat capacity measurement is about 0.02 percent and the sensitivity in the temperature measurement is about 10^{-5}K.

16310. Berger, R. E., **Dynamic strain gage measurements on ophthalmic lenses impacted by low energy missiles,** *J. Opt. Physiolog. Opt.* **53,** No. 6, 279-286 (June 1976).

Key words: drop-ball test; impact; lens; ophthalmic lens; quasi-static theory; strain gage measurements.

Strain distributions on impacted ophthalmic lenses were measured with strain gages. The strain distributions, which resulted from impacts produced with a special apparatus, were shown to be comparable to those which arise in the FDA drop-ball test. The measured strain drops off very rapidly away from the impact point, implying that only a small part of the lens is really being tested. The results are in good agreement with the quasi-static predictions. The effect of differences in lens power, of input kinetic energy, and of inserting the lens in a polyethylene bag are also investigated.

16311. Berger, R. E., **The role of edge failures in impact testing of ophthalmic lenses,** *J. Am. Optometric Assoc.* **47,** No. 5, 599-605 (1976).

Key words: drop-ball test; edge; fracture; impact; ophthalmic lenses; shape.

The role of edge mode failures in drop-ball testing of ophthalmic lenses was investigated. The relative effects of lens shape and type of edging operation were determined by comparing the impact performance of groups of lenses. Strain gages were mounted on the edges of several lenses to determine the applied tensile stresses. The results were reviewed in the context of the flaw distribution theory. As expected, more breakage was observed for those edging processes which introduce more severe flaws and for those lens shapes for which higher edge stresses were measured. It was also observed that the search theory of impact testing is applicable for edge flaws as well as for surface flaws (a lens sustains many impacts before it fractures; the ball is searching for a weak spot on the lens).

16312. Bennett, L. H., Kahan, D. J., Carter, G. C., **Alloy phase diagram data,** *Mater. Sci. Eng.* **24,** 1-17 (1976).

Key words: alloy; metallurgy; phase diagram.

An annotated list of references including the major compilations of data on alloy phase diagram, crystallography, and thermodynamics and some useful reviews and theoretical discussions of alloy phase diagrams is presented.

16313. Wardell, J. R., Wilmot, G. B., Haar, L., Klein, M., **Thermodynamic data for interior ballistics calculations,** *Proc. 12th JANNAF Combustion Meeting, Newport, RI, July 25, 1975,* pp. 363-390 (Chemical Propulsion Information Agency, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, 1976).

Key words: equation of state; interior ballistics; water.

The effect on theoretical interior ballistic calculations of real gas corrections to ideal gas thermodynamic quantities is considered. The equation of state of Haar and Shenker for dense spherical gases is generalized to nonspherical gases and applied to water. The agreement with available data is quite good. At 2000 K and 300 MPa (44,000 psi) our theoretical ratio of specific heats differs from that obtained using a simple virial equation of state by 5 percent. This corresponds to a 3.5 percent change in muzzle velocity and maximum pressure. The corresponding difference in Cv is only 2 percent.

16314. Bur, A. J., **Measurements on the dynamic piezoelectric properties of bone as a function of temperature and humidity,** *J. Biomech.* **9,** 495-507 (Sept. 1976).

Key words: bone; dispersion phenomena; Maxwell-Wagner polarization; piezoelectric *d* constant; piezoelectricity; relative humidity; temperature.

The utilization of piezoelectricity as a clinical or diagnostic tool in medicine and dentistry is dependent upon an adequate quantitative description of the piezoelectric coefficients. Here, measurements of the dynamic piezoelectric *d* constant, $d^* = d' - id''$, for bovine bone are presented as a function of temperature (20-60 °C), relative humidity (r.h.) (33-98%), frequency of applied stress (10^{-2}-10^{2} Hz), and sample orientation. The anisotropic character of cortical bone requires that *d* be expressed as a matrix containing 18 coefficients. Dispersion phenomena, i.e. $d'' \neq 0$, are present in these coefficients for our frequency-temperature-r.h. range. At low r.h. ($\leq 75\%$), d_{12} and d_{13} show little or no dispersion ($d'' = 0$), whereas varying degrees of relaxation are observed in the other coefficients. The d_{14} shear term is notable for a large dispersion at $f = 40$ Hz, $T = 38.6$ °C and 55 percent r.h., for which d''_{14} is negative. The negative imaginary coefficient means that energy is being gained in the 14 coefficient. The change in d_{14}, with a change in temperature and/or r.h., is attributed to a change in sample water content. For 98 percent r.h., the low frequency data ($f < 10$ Hz) are dominated by a polarization which varies as the reciprocal of the frequency. This polarization is attributed to an interfacial or Maxwell-Wagner polarization which occurs as a result of ionic conduction under the influence of the piezoelectric polarization field.

16315. Pierman, B. C., Bryson, J. O., **Building safety research at the National Bureau of Standards,** *Prof. Safety Mag.*, pp. 13-16 (Sept. 1976).

Key words: accidents; buildings; construction; maintenance; research accidents; safety.

This article summarizes the work that is accomplished in the Center for Building Technology to enhance the inherent safety of buildings in the United States. Aspects of user as well as worker safety resulting from building construction, use, maintenance, repair and retrofit are discussed. Research goals and methods, resulting in the greatest impact on overall safety in buildings are enumerated. Specific research projects are summarized.

16316. Margolis, S. A., Howell, B. F., Schaffer, R., **Purification and analysis of the purity of NADH,** *Clin. Chem.* **22,** No. 8, 1322-1329 (1976).

Key words: ADP; ADP-ribose; chromatography; impurities in NADH preparations; NADH stability; preparative chromatography on DEAE-cellulose; spectrophotometric properties of pure NADH.

We developed an analytical reverse-phase high-performance liquid chromatographic procedure for rapid assessment of the purity of NADH. The method completely separates adenosine monophosphate and adenosine diphosphoribose from NADH. By use of this analytical technique we found that preparative chromatography on DEAE-cellulose gives NADH that is free from adenine nucleotides as well as other impurities that commonly are present in NADH. The absorbance ratio at 260 and 340 nm of the purified NADH in 1.8 mmol/liter ammonium carbonate is 2.261 ± 0.002 (± 1 SD).

16317. Clark, E. J., Ballard, D. B., Embree, E. J., **SEM examination of an overheated aluminum wired electrical receptacle,** (Proc. 34th Annual Electron Microscopy Society of America Meeting, Miami Beach, FL, Aug. 9-13, 1976), Paper in *34th Annual Proceedings Electron Microscopy Society of America,* G. W. Bailey, Ed., pp. 454-455 (Claitor's Publ. Div., Baton Rouge, LA, 1976).

Key words: aluminum wire; nondispersive x-ray analysis; overheated receptacle; scanning electron microscope.

A typical household electrical receptacle wired with aluminum cable overheated during current cycling tests. It was studied for evidence of the cause of failure. The surfaces of the materials in the electrical path were examined by scanning electron microscopy and energy dispersive x-ray analysis and were found to contain corrosion products of the base materials. Chlorine was also present on the surfaces. A piece of the insulation was also examined. An explanation for the presence of chlorine in the corrosion products is suggested.

16318. Waterhouse, R. V., Cook, R. K., **Diffuse sound fields: Eigenmode and free-wave models,** *J. Acoust. Soc. Am.* **59,** No. 3, 576-581 (Mar. 1976).

Key words: acoustical energy density; acoustics; diffuse sound fields; reflection and interference of sound; room acoustics theory; sound fields.

The diffuse sound field as used in standard measurements in reverberant enclosures has been analyzed in terms of two different models, the eigenmode and the free-wave models. Recently the question has been raised as to the extent to which these models are consistent. To investigate these matters, the energy density as a function of position is calculated for axial, tangential, and oblique modes in a rectangular enclosure. The results show that, for a sound field consisting of several overlapping oblique modes, excited by a narrow band of noise, increases of mean sound pressure levels at the walls, edges, and corners of the enclosure are predicted that are in agreement with the results of the free-wave analysis and experiment. It is concluded that the two models are consistent. The implications of the models, regarding the spatial uniformity of energy, are discussed.

16319. Davis, R. M., **The computer serves, the consumer relishes,** *Comput. Dec.*, pp. 31-34 (May 1975).

Key words: automation; consumers; innovation; institutional barriers; productivity; service sector.

This paper deals with automation in the Service Sector. Consumers today are more dissatisfied with the services which they "buy" than the products they procure. The Service Sector is defined as well as the technologies of automation. It surveys the spread of automation in the United States as well as the institutional barriers impeding this spread. Automation has provided one of the best means for improving the quality of services and productivity in the Service Sector. A concern today is that people may become the victims rather than the masters of automation. To escape such a fate we must decide what we wish for ourselves and apply automation to achieve our goals.

16320. Wiese, W. L., Younger, S. M., **Atomic oscillator strengths in fusion plasma research,** (Proc. IVth Int. Conf. on Beam-Foil Spectroscopy, Gatlinburg, TN, Sept. 15-19, 1975), Paper in *Beam-Foil Spectroscopy*, I. A. Sellin and D. J. Pegg, Eds., **2,** 951-960 (Plenum Publ. Corp., New York, NY, 1976).

Key words: atomic oscillator strengths; beam-foil spectroscopy; fusion plasma research; plasma radiative losses; sodium isoelectronic sequence; Tokamak plasmas.

In the Tokamak devices used in fusion plasma research, highly ionized heavy metal impurities are observed which have detrimental effects on the plasma behavior, such as strong radiative energy losses. Thus, the radiative properties of impurity species, especially their atomic oscillator strengths, have assumed great importance. An effective approach to obtain these quantities appears to be the extension of theoretical methods to highly ionized species, e.g., by the application of nuclear charge dependent techniques. At some point, however, relativistic effects come into play which are largely unexplored. Another possibility is to utilize the regularities of atomic oscillator strengths along isoelectronic sequences to extrapolate to more highly ionized species. Again, relativistic effects will make these extrapolations uncertain. Thus, some key experimental data are urgently needed. Beam-foil spectroscopy has the potential for acquiring such data, but it will be taxed to its limits. The data needs will be reviewed, and it will be shown that combinations of beam-foil results, theoretical values, and systematic trend studies along isoelectronic sequences may lead to useful data for very highly ionized species.

16321. Schneider, S. J., Jr., **Materials properties determination: Transport properties, phase equilibria and slag properties,** *Proc. NSF-OCR Engineering Workshop on MHD Materials, Cambridge, MA, Nov. 20-22, 1974*, pp. 150-167 (Massachusetts Institute of Technology, Cambridge, MA, 1975).

Key words: diffusion; electrical conductivity; magnetohydrodynamics (MHD); phase equilibria; transport properties; vaporization; viscosity.

The combination of high temperatures and high velocity gases containing reactive chemical species produces a very severe environment within a MHD generator. Containment and operating materials must resist not only erosion through vaporization and corrosion by alkali and slag attack, but also must possess the requisite physical properties necessary for generator operation. The design of a materials device (e.g. electrode) to withstand the rigors of these conditions requires knowledge and proper utilization of the basic physical and chemical properties of candidate materials translated to within the context of an operating engineering system. This paper concentrates on some important aspects of materials behavior and characteristics which are thought to be influential or paramount in ensuring long life and operability of the MHD generator. First of all information on the transport properties viscosity, vaporization, diffusion, and electrical conductivity is necessary to effectively design an electrode-insulator system which will operate satisfactorily over the long term. Viscosity of slags is important to the erosive and corrosive wear of the containment materials as well as to the temperature gradients at interfaces. Vaporization (and condensation) mechanisms will determine the chemical compositions at boundary layers and hence influence the ultimate degradative processes which take place. Diffusion rates of species to and from a given location such as interior layers will dictate the long term stability of these sections. Electrical conductivity of electrodes, insulators and slags and their reaction products is of overriding importance to the operability and performance of the generator. Second the phase equilibria of contacting phases, either solid, liquid or gas, will establish to resulting phase assemblages and hence the "worst case situation." Knowledge of the pertinent phase relations allows incorporation of design features which will delete or minimize degradative reactions. Each of the materials properties are interrelated and must be considered together for proper design and operation of a MHD generator. This paper discusses each of these properties of materials appropriate to clean fuel generators and for coal fuel applications.

16322. Klose, J. Z., **Measurement of atomic uranium lifetimes for isotope separation,** (Proc. SPIE/SPSE Tech. Symp. on Ultra High Power Lasers for Practicable Applications, Reston, VA, Mar. 22-23, 1976), *SPIE 76*, 150-155 (Society of Photo-Optical Instrumentation Engineers, Palos Verdes Estates, CA, 1976).

Key words: atomic beam; delayed coincidence; imprisonment; lifetime; mean life; resonance radiation; transition probability; U I; uranium.

Following a brief discussion of uranium isotope separation using lasers, the delayed coincidence method of measuring atomic mean lives with pulsed electron beams utilized here is described along with the beam source used to supply the free uranium atoms for measurement. Experimental details involved in the lifetime measurement are next discussed followed by the effect of resonance radiation imprisonment on the measured lifetimes. Finally, lifetime measurements involving the 3584.9 Å and 5915.4 Å transitions in natural uranium are described, and the previously reported result of 7.3 ± 1.1 ns for the mean life of the upper level of the 3584.9 Å transition (27886.99 cm^{-1}) is presented.

16323. Unassigned.

16324. Christ, B. W., Swanson, S. R., **Alignment problems in the tensile test,** *J. Test. Eval.* **4,** No. 6, 405-417 (Nov. 1976).

Key words: alignment; stresses; tension tests.

Uniaxial tensile testing is a method used throughout the world to measure the strength and ductility of materials. An important aspect of uniaxial tensile testing which often goes unrecognized is test system alignment. Poor alignment can significantly influence test results at small strains, especially the fracture strengths of materials in a brittle state. The purpose of this review paper is to enable a reader to identify sources of misalignment, recognize the effects of misalignment on tests results, evaluate the extreme surface bending strains and stresses, and become acquainted with some techniques for reducing misalignments to within tolerable limits. Numerous references are made to the literature which describes how misalignment may be influenced by couplings in the loading train and by specimen design. A quantitative assessment of the devices and techniques discussed in this literature is made in those cases where sufficient data have been provided. The literature surveyed indicates that misalignment in carefully designed and precisely machined testing systems ranges between 3 and 15 percent bending. The need for reporting the misalignment at which a given test result is obtained is pointed out.

16325. DeSpain, H. E., Garfinkel, S. B., **Calibration of detectors for argon-41,** *Proc. Noble Gases Symp., Las Vegas, NV, Sept. 24-28, 1973,* pp. 155-159 (1973).

Key words: argon; calibration; detector, radioactive argon; ionization chamber; sodium-22; standard reference materials.

Most nuclear reactors produce argon-41 during their operation. For many, it is the largest single gaseous radioisotope released outside the reactor. It is essential, therefore, to know the concentration of this gas—both in working areas for the protection of reactor personnel and in reactor effluents for environmental protection. For this reason, it was important to develop a rapid and easy method to precisely measure the concentration of argon-41, wherever it may be found.

The radioactivity of an irradiated sample of argon was assayed by comparing it to an NBS Standard Reference Material of sodium (^{22}Na). The argon-41 was then transferred to an ionization chamber, and an accurate calibration of the response of the ion chamber was made. This chamber was subsequently used to calibrate other detectors, including the stack monitor for the NBS 10 MW heavy-water research reactor. The method used does not require an accurate knowledge of the neutron flux density, cross section, nor volume of gas irradiated for the calibrating samples. Also, the activated argon does not have to be transferred to another container before assaying. Furthermore, this method allows for quick and repeated recalibrations and measurements whenever required. The results to date have been excellent.

16326. Mamrak, S. A., **A predictive response time monitor for computer networks,** *Proc. 3d Int. Conf. on Computer Communication, Toronto, Canada, Aug. 3-6, 1976,* pp. 626-630 (1976).

Key words: computer networks; minicomputers; Network Access Machine; network services; response time; response time predictions.

A predictive response time module to assist users of a heterogeneous network of computers is proposed. The network user is able to query this dynamically updated software module to obtain current information relating to the busyness of time sharing systems in the network. In particular, the amount of time required on these systems to run various classes of computing applications is displayed.

The implementation of the module is proposed as an extension of a Network Access Machine (NAM) developed by the Computer Networking Section at the National Bureau of Standards. The NAM is a minicomputer which assists the network user in obtaining network services. The response time module will produce either a narrative description of the general response time characteristics of specified network systems or comparative lists of response times for running short and long FORTRAN, COBOL and BASIC jobs on those systems.

The feasibility of the design and implementation plan was verified by response time measurement experiments conducted on a DEC System-10. A measure of system busyness called "Percent CPU Null Time" was found to be a satisfactorily accurate parameter on which to base response time predictions for the FORTRAN, COBOL and BASIC jobs mentioned above.

16327. Lyerla, J. R., Jr., VanderHart, D. L., **^{13}C spin-lattice relaxation studies of perfluoroalkanes,** *J. Am. Chem. Soc.* **98,** No. 7, 1697-1700 (Mar. 31, 1976).

Key words: chemical shift; fluoroalkanes; molecular dynamics; NMR; relaxation.

To obtain information on the rigidity of perfluoroalkanes in the liquid state, ^{13}C spin-lattice relaxation times (T_1) and $^{13}C-^{19}F$ nuclear Overhauser enhancements (NOE) of individual carbon atoms in liquid *n*-C_6F_{14}, *n*-C_7F_{16}, and *n*-C_8F_{18} have been measured at 39 °C. Analysis of the relaxation results indicates that the only internal motion occurring on the time scale of overall molecular reorientation is rotation of the CF_3 group. Comparison of these results with *n*-alkane relaxation data provides evidence for higher intramolecular rotational potential barriers in the perfluoroalkyl chain. In addition to the relaxation results chemical shifts and resonance assignments are reported for the three perfluoroalkanes as well as 1H-*n*-C_7F_{15}.

16328. Oettinger, F. F., Blackburn, D. L., Rubin, S., **Thermal characterization of power transistors,** *IEEE Trans. Electron Devices* **ED-23,** No. 8, 831-838 (Aug. 1976).

Key words: current crowding; hot spots; reliability; safe operating area limits; second breakdown; semiconductor devices; thermal resistance; transistor, power.

The idealized concept of thermal resistance as applied to power transistors is discussed. This concept must be used with care because two of the basic assumptions made in applying the concept to these devices are not valid. Contrary to these assumptions, it is shown that 1) the junction temperature of a power transistor is never spatially uniform, and 2) no unique value of thermal resistance can be defined for all operating conditions.

Also, various electrical methods for measuring the junction temperature (thermal resistance) of power transistors are discussed with the emphasis placed on the emitter-only switching measurement technique, which is the preferred standard method of measurement. In addition, the generation and meaning of forward-biased safe-operating-area (SOA) limits are discussed, and it is shown that because of the presence of current crowding and the associated hotspots, the specified SOA limits often permit devices to be operated at dangerously high junction temperatures. Electrical measurement methods capable of determining the peak juntion temperature as well as determining the onset of current crowding are described, and it is shown how these methods might be used for the generation of improved SOA limits.

16329. Sibley, E. H., **The development of data-base technology,** *Assoc. Comput. Mach. Comput. Surveys Editorial* **8,** No. 1, 1-5 (Mar. 1976).

Key words: data base; data integration; implementation; modelling; technology; terminology.

Here we attempt an integrated approach to a very disoriented field. Problems abound: differences in terminology, differences in modelling, and differences in implementation confuse the potential user, who is faced with almost unanswerable questions. Such problems are found in any evolving technology, especially when it is associated with a fast developing industry, such as computing; while some appear more philosophical than real, others arise from poor understanding of new concepts. Here we shall try to answer some of the questions and reduce the confusion. But obviously, one issue of Computing Surveys cannot be all encompassing; data technology is a field which already boasts hundreds of articles, and text books by the dozen. Thus this issue confines itself to an explanation of various models of data-base systems, showing their differences and similarities, while trying to relate the models to their implementation in current commercial and experimental systems.

We were faced with one major problem in trying to provide an integrated issue: every model uses its own terminology. We therefore decided to attempt to use both a common terminology and a single example wherever possible. This is by no means a simple task; we must not only define terminology and apply it to descriptions of various models, but also show how these terms differ from those used by others in discussing the same ideas: there is no standard, and we are forced to be arbitrary.

16330. Fry, J. P., Sibley, E. H., **Evolution of data-base management systems,** *Assoc. Comput. Mach. Comput. Surveys* **8,** No. 1, 7-42 (Mar. 1976).

Key words: data base; data-base machines; data-base management; data definition; data dictionary; data independence; data manipulation; data model; distributed data base; generalized processing.

This paper deals with the history and definitions common to data-base technology. It delimits the objectives of data-base management systems, discusses important concepts, and defines terminology for use by other papers in this issue, traces the development of data-base systems methodology, gives a uniform example, and presents some trends and issues.

16331. Mielenz, K. D., **Comments on spectrometry nomenclature,** *Anal. Chem.* **48,** No. 7, 1093-1094 (June 1976).

Key words: analytical chemistry; nomenclature; photochemistry; photometry; physical optics; radiometry; spectrometry; spectroradiometry.

Several inconsistencies in the nomenclatures used in analytical spectrometry and in physical optics are pointed out. Specific proposals are made to correct these inconsistencies.

16332. Stevens, J. G., Travis, J. C., DeVoe, J. R., **Mössbauer spectrometry,** *Anal. Chem.* **44,** No. 5, 384R-406R (Apr. 1972).

Key words: chemical applications; instrumentation; Mössbauer spectrometry; nuclear parameters; recent advances; tables; theory.

A comprehensive review is given of the 1969-70 Mössbauer spectroscopy literature relating to chemistry. The key features of chemical studies are reported in tabular form, and theoretical and instrumental achievements are treated in the textual account. A total of 771 references are cited.

16333. Mielenz, K. D., Mavrodineanu, R., Cehelnik, E. D., **Efficient averaging spheres for visible and ultraviolet wavelengths,** *Appl. Opt.* **14,** No. 8, 1940-1947 (Aug. 1975).

Key words: averaging sphere; diffusing effectiveness; efficiency; fluorescent wavelength converter; photometry; spectrophotometry; ultraviolet; visible.

On the basis of a theoretical analysis that identifies the design criteria for optimization of efficiency, an averaging sphere with a barium-sulfate target was constructed that has an efficiency of 80-90 percent in the visible. In spite of the decreased reflectance of the sphere walls in the uv, this sphere is still 30 percent efficient at 300 nm and, thus, can be used for near-uv work. For applications below 300 nm, a cell containing a fluorescent dye is placed inside the sphere in order to shift the incident radiation into the longer wavelength region in which the reflectance of the sphere walls is higher. The use of this fluorescent wavelength converter, which was designed so that the sphere remains usable in the visible, resulted in a sphere efficiency of about 20 percent in the region between 200 nm and 300 nm and 50 percent in the visible. The averaging properties of these spheres were found to be adequate for high-accuracy photometric measurements.

16334. Kubota, M., Golightly, D. W., Mavrodineanu, R., **A rapid wire-loop method for determination of lead in paint by atomic absorption spectrometry,** *Appl. Spectrosc.* **30,** No. 1, 56-63 (1976).

Key words: atomic absorption; determination; lead; paint; wire loop.

A simple, rapid method is described for the determination of lead in paint. Lead is extracted from paint chips, or liquid paint, into an acidic aqueous solution. Ten microliters of sample solution is transferred onto a platinum-rhodium wire loop, and the solvent is evaporated by placing the loop in a small resistance heater. The loop then is introduced into a premixed acetylene-air flame, and lead absorption at 283.3 nm is measured. Physical and chemical parameters affecting the accuracy and precision of the method are discussed. Accurate determinations of lead are possible for concentrations ranging from 0.1 to 1 μg/10 μl of solution. The wire loop method is adaptable to a simple screening method for analysis of paints in mobile or on-site laboratories.

16335. Lawn, B. R., **A model for the wear of brittle solids under fixed abrasive conditions,** *Wear Short Commun.* **33,** 369-372 (1975).

Key words: abrasion; brittle surfaces; chipping fracture; hardness; wear rate.

An explicit model for the wear of brittle surfaces under fixed abrasive conditions is presented in terms of indentation fracture concepts. The predicted wear rate for glass agrees with that observed experimentally to within an order of magnitude. Some implications concerning the parameters which influence the abrasion process, particularly the hardness, are discussed.

16336. Powell, F. J., **Trends in heating, ventilating and air-conditioning,** *Proc. 5th CIB Congress on Research into Practice. The Challenge of Application, Paris, France, June 1971*, pp. 646-648 (1971).

Key words: air-conditioning; heating.

The rapid growth of science and technology in recent years has improved the means by which man can control his environment, but it has also created a rising tide of expectations on his part for a better quality of environment. The merging of the means and the desire for better environment is one of the strong current trends with respect to the equipment and systems used for heating and cooling of buildings. This paper describes some of the current efforts and future needs, with special emphasis on the use of a dynamic approach and computers, for promoting this convergence of potential and desire, as a response to the prepared papers on New Trends in Heating and Ventilation for the 5th Congress of CIB.

16337. Cassatt, W. A., Yap, W. T., Reed, W. P., Mills, S. A., **Results of measurements on fine particle standard reference materials at NBS,** *Powder Tech.* **13,** 27-31 (1976).

Key words: fine particle standards; particle concentration; particle counting; particle size; particulates; standard reference materials.

The current efforts at the National Bureau of Standards to produce a standard reference material (SRM) for accurate size and concentration measurements in fine particle technology are discussed. Two batches of latex spheres are being characterized as calibration materials for "flow-through" particle counters. The criteria for selecting these materials, and the choice of the packaging techniques are described. The methods of measuring the size of the particles, which will be furnished in aqueous suspension, are discussed along with the measurement data.

16338. Garbern, D., Kelly, G. E., **Dynamic efficiency of a gas-fired boiler,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II*, Paper C.1, pp. 330-335 (Purdue Res. Indation, Lafayette, IN, 1976).

Key words: dynamic boiler efficiency; efficiency vs cycling rate; efficiency vs heating load; gas-fired boiler.

The effect of cycling rate and part-load operation on the efficiency of a gas-fired, cast iron, hydronic boiler was examined in the laboratory. The boiler studied has an input rating of 300,000 BTU/hr (316,500 KJ/hr). Experimental curves are presented which show how the measured efficiency varied with the rate of cycling at several different heating loads. It was found that the cycling rate had only a slight effect on the part-load efficiency of the gas-fired boiler.

16339. Fong, J. T., Zapas, L. J., **Chemorheology and the mechanical behavior of vulcanized rubbers,** *Trans. Soc. Rheol.* **20:3,** 319-338 (1976).

Key words: anisotropy; chemorheology; degradation; elasticity; finite deformation; incompressible materials; permanent set; polymers; rubbers, viscoelasticity.

The objective of this work is to represent general nonlinear viscoelasticity by a model based on a modified two-network theory. As a basic problem we examine Neubert and Saunders' data (1958) on the permanent set of crosslinked natural rubber samples after heating in a state of pure shear or simple extension. It is evident that the preferred configuration changes with time of heating. Our approach is to associate the preferred configuration with an internal measure of length in an initially isotropic material which becomes anisotropic after heating in a deformed state. Using Ericksen and Rivlin's work (1954) on anisotropic materials and a strain energy function which reduces for isotropic materials to Rivlin and Saunders' function (1951), we show an excellent consistency with the Neubert and Saunders' data. We also show consistency with some more recent data due to Djiauw and Gent (1973).

16340. Cram, S. P., Chesler, S. N., **Coupling of high speed plasma chromatography with gas chromatography,** *J. Chromatogr. Sci.* **11,** 391-401 (Aug. 1973).

Key words: chromatography; coupling of high speed plasma; gas chromatography; high speed plasma; plasma.

A gas chromatograph has been coupled to a new rapid scan (20 msec) plasma chromatograph without the use of a molecular separator. The sensitivity, noise, and signal-to-noise ratio for Freons analyzed on the plasma chromatograph were found to be relatively insensitive to changes in the plasma chromatograph carrier and drift gas flow rates, and a unique mass calibration curve for the E-series Freons is reported. The sensitivity of the plasma chromatograph and GC FIDs are compared for Freons and the utility of the plasma chromatograph in identifying GC effluents and peak fractionation is reported. A comparison is made between gas chromatography/plasma chromatography and GC/MS.

16341. Dragoo, A. L., **Steady thermocapillary convection cells in liquid drops,** *Proc. Int. Colloquium on Drops and Bubbles, Pasadena, CA, Aug. 28-30, 1974*, pp. 208-226 (1974).

Key words: convection; drops; Marangoni effect; surface tension; thermocapillarity.

A nominally spherical drop is used as a model for a theoretical analysis of thermocapillary convection and for estimates of convective flow rates in "levitated" melts at zero-g. Since in practice temperature fields and the resulting convective flow can be more complicated than the simple vertical temperature gradient and the single vortex ring, respectively, the convective flow arising from a general steady-state temperature field is analyzed. Expressions for the components of a steady velocity field are obtained by adapting the analytical method of Miller and Scriven. The vortex rings are illustrated by means of typical streamlines for the simpler, more symmetric temperature fields. The circulation time is introduced as a measure of the rate of circulation in a convection cell and typical values are given for several materials.

16342. Kelnhofer, W. J., Hunt, C. M., Didion, D. A., **Determination of combined air exfiltration and ventilation rates in a nine-story office building,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II, Paper B.4*, pp. 322-328 (Purdue Res. Indation, Lafayette, IN, 1976).

Key words: air infiltration; energy conservation; measurement techniques; ventilation of office buildings.

The sulfur hexaflouride tracer-gas technique, which has been used previously for determining air infiltration rates in residential buildings, was applied to a nine-story office building of modern design. The building has sealed windows with openings only on the first level and on the roof, and is mechanically ventilated with a variable air volume system. Tests were run during the cooling season by introducing the tracer gas into the main trunk of the air supply system and measuring the concentration decay rate in the return air. Infiltration rates were determined with outside air vents open and closed. To check the results, a second independent method was used, which involved direct measurement and calculation of infiltration rates.

16343. Schaffer, R., **The development of a clinical reference method for glucose in serum,** *Pure Appl. Chem.* **45,** 75-79 (1976).

Key words: clinical reference method; definitive glucose method; glucose in serum; isotope dilution-mass spectrometry; serum glucose.

The progress achieved as of July 1975 on the development of a clinical reference method for glucose is presented; this effort originated as a subcommittee function of the American Association of Clinical Chemists. The hexokinase glucose-6-phosphate dehydrogenase method for determining glucose was selected as the candidate clinical reference method. Its use in all laboratories performing the round-robin tests has provided high precision values. Its accuracy is being evaluated against the results of isotope dilution-mass spectrometry (ID-MS) as the definitive method for glucose. Work as yet incomplete shows some erratic differences between the ID-MS and the candidate clinical method. More is to be done with ID-MS to ensure the validity of its values before further efforts on the clinical reference method are undertaken.

16344. Hertz, H. S., May, W. E., Chesler, S. N., Gump, B. H., **Analysis of μg/kg (ppb) level hydrocarbons in intertidal zone sediments and water by gas chromatography-mass spectrometry,** *Proc. 23d Annual Conf. on Mass Spectrometry and Allied Topics, Houston, TX, May 25-30, 1975,* pp. 663-665 (1975).

Key words: gas chromatography-mass spectrometry; hydrocarbons; petroleum; water pollution.

The low concentration of hydrocarbons anticipated in pollution baseline studies necessitates the development of analytical techniques sensitive at the sub-microgram/kilogram level. Techniques which involve dynamic headspace sampling and subsequent GC/GC-MS analysis have been developed in this laboratory. Sample components are separated from the matrix in a closed system and concentrated on a porous polymer precolumn, free from large amounts of solvent and ready for GC-MS analysis. Applications of this methodology to the identification of μg/kg level hydrocarbons in a baseline study are discussed.

16345. Currie, L. A., **The measurement of environmental levels of rare gas nuclides and the treatment of very low-level counting data,** *IEEE Trans. Nucl. Sci.* **NS-19,** No. 1, 119-126 (Feb. 1972).

Key words: argon-37; atmospheric mixing; blank corrections; cosmic ray reactions; effectively zero background; environmental radioactivity; low-level counting statistics; radioactive rare gases; reduced activity.

The radioactive isotopes of the rare gases provide unique geophysical and meteorological information concerning the properties and history of our (atmospheric) environment. The extremely low activity levels, however, require very special methods of measurement, experiment design, and data interpretation.

Following an examination of the decay characteristics and atmospheric abundances of Kr and Ar radioisotopes, the question of experiment planning and data interpretation in the "extreme Poisson" (few counts) region is considered. A reduced activity plot is offered as an aid for making rapid evaluations and decisions in this region. The concept of an effectively zero background is illustrated by means of atmospheric ^{37}Ar data.

Finally, the problem of the blank is examined, and the merits and deficiencies of three alternative approaches are discussed, again with special emphasis on the measurement of ^{37}Ar in Nature.

16346. Smith, C. N., Placious, R. C., Mills, R. M., **X-ray systems for bomb disarmament,** *NILECJ-STD-0603.00,* 11 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, June 1975).

Key words: bomb disarmament; explosive; x-ray equipment; performance standard, EOD.

Performance requirements and methods of test have been established for x-ray equipment used for bomb disarmament. Requirements are specified which indicate the equipment's suitability for use in the specified application.

16347. Chi, J., **Computer simulation of fossil-fuel-fired boilers,** *Proc. Conf. on Improving Efficiency and Performance of HVAC Equipment and Systems for Commercial and Industrial Buildings, Purdue University, Lafayette, IN, Apr. 12-14, 1976, II, Paper C.2,* pp. 336-346 (Purdue Res. Foundation, Lafayette, IN, 1976).

Key words: boilers; computer simulation; DEPAB (DEsign and Performance Analysis of Boilers); energy saving measures; performance at part load; seasonal efficiency.

After an analytical boiler model is established, which is both an adequate representation of the physical system and capable of reasonably simple mathematical description, governing equations based upon this model are derived. A computer program DEPAB (DEsign and Performance Analysis of Boilers) is then developed to simulate boiler operations. DEPAB is designed to predict the performance of both the gas-fired and oil-fired hydronic boilers. Accuracy of results from computer simulation has been verified by the experimental data on a gas-fired boiler. Verification for the oil-fired boiler will be made in the future, when experimental data become available to the author. Examples are given to illustrate applications of the program to examine quantitatively the effects of design and operating variables on performance and seasonal fuel economy of heating boilers for buildings. It was found that considerable seasonal savings in fuel can often be achieved by performing certain modifications to the existing boilers.

16348. Johnson, C. R., **Normality and the numerical range,** *Linear Algebra and Appl.* **15,** 89-94 (1976).

Key words: eigenvector; normal matrix; numerical range; orthogonal; spectrum.

It is well known that if A is an n by n normal matrix, then the numerical range of A is the convex hull of its spectrum. The converse is valid for $n \leq 4$ but not for larger n. In this spirit a characterization of normal matrices is given only in terms of the numerical range. Also, a characterization is given of matrices for which the numerical range coincides with the convex hull of the spectrum. A key observation is that the eigenvectors corresponding to any eigenvalue occurring on the boundary of the numerical range must be orthogonal to eigenvectors corresponding to all other eigenvalues.

16349. Clifton, J., Frohnsdorff, G., **Polymer-impregnated concretes,** Chapter 12. Special Review in *Cements Research Progress 1975,* pp. 173-196 (American Ceramic Society, Columbus, OH, 1976).

Key words: concrete; concrete-polymer systems; polymers; polymer-impregnated concrete; sulfur-impregnated concrete.

This is a comprehensive literature review on developments in the science and technology of polymer-impregnated concretes, up to December 1975. Altogether 116 references have been reviewed.

16350. Evans, J. M., Jr., **The role of standards in integrated manufacturing systems,** (Proc. Twelfth Annual Meeting and Tech. Conf. of the Numerical Control Society, Washington, DC, May 19-21, 1975), Paper in *Progress through Government Education and Industry Cooperation, NC/CAM EXPO 1975*, pp. 211-217 (Numerical Control Society, Inc., Spring Lake, NJ, 1975).

Key words: automation; computer aided manufacturing systems; computer integrated manufacturing systems; interfaces; motivation for standardization; standards.

Computer controlled integrated manufacturing systems offer increases in labor productivity of up to an order of magnitude or more and cost reductions of factors of 2 or 3 or more. Large user industries are building such systems; however, the cost of special engineering and computer programming and the risk involved preclude medium and small firms from gaining these benefits. The role of standards in constructing integrated systems with components from competitive manufacturers is discussed and the NBS program aimed at the development of those standards is reviewed.

16351. Gerhold, W. F., McCann, J. P., Williamson, W. E., **Report on corrosion of underground telephone cable shielding materials in soil environment after exposure for four years,** *Proc. NACE Conf., Chicago, IL, Mar. 5-9, 1973*, pp. 1-33 (National Association of Corrosion Engineers, Houston, TX 77027, Mar. 1974).

Key words: metal and plastic composites; metal composites, metals; soil corrosion, telephone cable shields; underground corrosion.

Four-year underground corrosion data on the performance at accepted and experimental telephone cable shielding specimens is tabulated and evaluated. The specimens include bare and coated metals or alloys as well as metallic composites. The specimens were uniformly prepared to expose the outer shielding test material to corrosion in a galvanic coupled and uncoupled condition. A replicate of each exposed cable shielding specimen is removed each year from six soil burial sites. The six soil burial sites are representative of a large segment of the various soil conditions existing in the United States.

16352. Gerhold, W. F., McCann, J. P., **Corrosion evaluation of underground telephone cable shielding materials,** (Proc. Int. Corrosion Forum on the Protection and Performance of Materials, Houston, TX, Mar. 22-26, 1976), *Corrosion/76*, Paper No. 31, pp. 31/1-31/62 (1976).

Key words: alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; underground.

Corrosion data is given on the performance of base and plastic coated metals intended for use as cable shields for buried telephone cable. The materials investigated on specially prepared specimens were buried for periods up to six years in six different soil environments. Metals tested included homogeneous plastic-bonded and metallurgically-bonded laminates. Some specimens were exposed bare (uncoated), while others had plastic coatings or other types of coatings on either one or both sides. Metals studied included aluminum, copper, low carbon steel and stainless steel alloys.

16353. Ogburn, F., **Metrication and the electroplaters,** *Plat. Surf. Finish*, pp. 669, 672-673 (July 1975).

Key words: electroplating industry, metrication of; metal finishing, metric system for; metrication, electrodeposition; metrication, electroplating; metrication, metal finishing; metric system, electroplating industry.

Under the impetus of American industry, the metric system is well on its way to becoming the dominant system of measurement in the United States. Metrication of the electroplating community will be a result of this and it has already begun. For electroplaters metrication will be relatively easy. Some difficulties are anticipated, but these can largely be avoided with appropriate planning by the AES, NAMF, MFSA, and ASTM.

16354. Escalante, E., Gerhold, W. F., **Galvanic coupling of some stressed stainless steels to dissimilar metals underground,** *Am. Soc. Test. Mater. Spec. Tech. Publ. STP* **576,** 81-93 (1976).

Key words: corrosion; galvanic; hydrogen embrittlement; soil; stainless steel; stress; stress-corrosion; underground.

Stainless steels, Type 301 half hard and Type 301 full hard, have been found susceptible to failure by hydrogen embrittlement when stressed as low as 40 percent of their yield strength and cathodically charged above 1 $\mu A/cm^2$ by galvanic coupling to a dissimilar metal in four years of exposure at six underground test sites. However, stainless steels Type 304 and alloys 26Cr-1Mo and 26Cr-6.5Ni were resistant under similar conditions. Failures by stress-corrosion cracking were not observed in any of the materials. Electrochemical measurements made periodically above ground are correlated with the subsequent visual examination of the specimens.

16355. Escalante, E., Gerhold, W. F., **The galvanic coupling of some stainless steels to copper—Underground,** (Proc. Corrosion/75, Toronto, Ontario, Canada, Apr. 14-18, 1975), *Mater. Perform.* **14,** No. 10, 16-20 (Oct. 1975).

Key words: copper; corrosion; galvanic corrosion; soil corrosion; stainless steel; underground corrosion.

On site underground tests at 6 widely differing sites were made of 26Cr-6.5Ni, Type 304 (18Cr-8Ni) and Type 409 (less than 11 Cr ferritic) coupled to commercially pure copper. Galvanic current tests were made over 3 to 4 years and retrieved specimens were examined in the laboratory. When exposure conditions made Cu anodic to the stainless, local corrosion was minimized. Pitting occurred on some stainless specimens at some sites. Type 409 pitted more than other alloys and copper was cathodically protected by stainless in some cases. Chloride-containing, poorly aerated soils (400-15,500 ohm cm) in a tidal marsh caused greatest attack. Cu lost 3 mils and pits formed were 1 to 5 mils deep; 409 perforated and lost 30 percent weight at one site and other alloys at the site pitted to less than 30 mils. Data indicate no increase in attack on stainless steels coupled to Cu over that on uncoupled specimens in same environments.

16356. Boettinger, W. J., Burdette, H. E., Kuriyama, M., Green, R. E., Jr., **Asymmetric crystal topographic camera,** *Rev. Sci. Instrum.* **47,** No. 8, 906-911 (Aug. 1976).

Key words: asymmetric; diffraction; intensifier; topography; x ray.

The practical aspects of asymmetric crystal topography are described. In this technique, asymmetric Bragg diffraction is utilized to obtain a monochromatic and well collimated x-ray beam large enough to cover the entire area of sample crystals. Thus, the recording of diffracted beams from a sample crystal provides topographic images of the entire sample crystal. Advantages of this technique are simplicity (no scanning device), excellent sen-

sitivity to crystal imperfections (strain fields), and versatility. Information is given on the general alignment of the camera, magnification of the x-ray beam width, preparation of the first crystal, and divergence of the beam due to the first crystal. The practical aspects of this topographic system are demonstrated using thick Cu and Ni crystals of various degrees of perfection. An inexpensive image intensifier is also described, which is used routinely to aid in the alignment of sample crystals.

16357. Segransan, P. J., Clark, W. G., Chabret, Y., Carter, G. C., **The Knight shift and nuclear spin relaxation of ^{61}Ni metal in the paramagnet phase,** *J. Phys. F: Metal Phys. Lett. to Ed.* **6,** No. 5, L153-L156 (1976).

Key words: Knight shift; magnetism; nickel; pulsed NMR; spin lattice relaxation.

Pulsed NMR measurements in a 99.54 at% ^{61}Ni enriched sample of Ni metal in the paramagnetic phase are reported for a wide range of temperatures (785-1520 K). The Knight shift ($\mathcal{K}$) follows an expected Curie-Weiss law $\mathcal{K}(T)=\mathcal{K}(\infty)+A_K/(T-T_c)$, where $\mathcal{K}(\infty)=(1.48\pm0.05)\%$, $A_k=-(560\pm10)\%$K, and $T_c=(662\pm10)$K. The d spin hyperfine field is found to be $-(108\pm8)$kG per Bohr magneton. The recovery of the magnetization following a comb of saturating pulses is $(150\pm50)\mu$s for the entire temperature range.

16358. Schaffer, R., **Calibrator product class standard,** *Proc. of the SAMA Calibrator Product Class Standard Forum and Stability Testing Workshop, Chicago, IL, Mar. 18-19, 1975,* 7 pages (Scientific Apparatus Makers Association, Washington, DC 20036, 1975).

Key words: calibration reference materials; calibrators; clinical control materials; clinical standards; consensus standards; reference materials.

A forum was held on the Product Class Standard for Calibrators. This Product Class Standard is closely derived from a National Committee for Clinical Laboratory Standards standard entitled "Calibration Reference Materials and Control Materials in Clinical Chemistry." The development of the standard was discussed.

16359. Corcoran, C. T., Langhoff, P. W., **Polynomial expansions for spectral densities,** *Chem. Phys. Lett.* **41,** No. 3, 609-614 (Aug. 1, 1976).

Key words: electron scattering; moment theory; photoabsorption/ionization; spectral densities.

Modified moments and polynomial expansions are employed in imaging the spectral densities that arise in electron-scattering and photoionization calculations.

16360. Evans, A. G., Clifton, J. R., Anderson, E., **The fracture mechanics of mortars,** *Cement Concrete Res.* **6,** No. 4, 535-547 (1976).

Key words: acoustical emission; fracture mechanics; mortars; polymer impregnated mortars; slow crack growth.

A fracture mechanics study of plain and polymer impregnated mortars has shown that the (slow and rapid) macrocrack propagation resistance of these materials is not significantly affected by mortar processing variables, such as water/cement ratio and curing time, but is strongly enhanced by polymer impregnation. Acoustic emission measurements have indicated the important role of microcracking in the fracture of both plain and impregnated mortars; with the susceptibility to microcracking being substantially retarded by polymer impregnation.

16361. Slater, J. A., **Data systems and fire casualty information,** *Proc. First Conf. and Workshop on Fire Casualties, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, May 28-29, 1975,* pp. 158-171 (Apr. 1976).

Key words: accident data; data systems; fabric flammability; FFACTS; fire accidents; fire data systems; fire hazards; fires; hazard analysis; NEISS; plastics flammability; product safety.

Four data systems are described in terms of their inputs and outputs. Each contains fire-related information which has been collected from all over the United States and is or will be computerized. All the systems are maintained by Federal Government agencies. The National Electronic Injury Surveillance System (NEISS) was developed by the Consumer Product Safety Commission. Based on a statistical sample of hospitals, NEISS includes data on fire-related injuries from consumer products. The National Fire Prevention and Control Administration is developing a National Fire Data System which will incorporate fire data from many sources such as the National Center for Health Statistics, fire incident reports and a national household fire survey. The Flammable Fabrics Accident Case and Testing System and the Plastics Fire Accident Case and Testing System were developed at the National Bureau of Standards in order to study, in-depth, fabric and plastics fire accidents. Both involve field investigations of fires, preparation of detailed case histories and retrieval, analysis and testing of samples. A possible conceptual framework developed by Bryan for analyzing fire data is briefly discussed.

16362. Lias, S. G., **Charge transfer to hydrogen halide and halogen molecules from atomic and diatomic ions,** *Int. J. Mass Spectrom. Ion Phys.* **20,** 123-137 (1976).

Key words: charge transfer; H-atom transfer reactions; hydrogen halides; ion molecule reactions; ion cyclotron spectrometry; rate coefficients.

The charge transfer from Xe^+, Kr^+, and Ar^+ to HI, HBr, HCl, Br_2, and Cl_2 and from O_2^+ and N_2^+ to HI, HBr, and HCl have been investigated. None of these reactant pairs undergoes a fast charge-transfer reaction. The probability of charge transfer for a given ion-molecule pair depends on the existence of a matching between the recombination energy of the reactant ion and energy level of the product ion. No effect of Franck-Condon factors on the probability of charge transfer could be inferred from these results.

The Kr^+, Ar^+, and N_2^+ ions also undergo the alternate reaction, $M^+ + HX \rightarrow MH^+ + X$, with the hydrogen halides, in competition with charge transfer. Except when charge transfer is favorable, the rate of this reaction is proportional to the reaction exothermicity.

A few preliminary results on the reactions of Xe^{2+}, Kr^{2+}, and Ar^{2+} ions with hydrogen halides and halogens are also reported.

16363. Buehler, M. G., Phillips, W. E., **A study of the gold acceptor in a silicon p^+n junction and an n-type MOS capacitor by thermally stimulated current and capacitance measurements,** *Solid-State Electron.* **19,** 777-788 (1976).

Key words: gold-doped silicon; measurement methods; MOS capacitor; p-n junction; semiconductor defects; silicon; thermally stimulated capacitance; thermally stimulated current.

The thermally stimulated current and capacitance responses of a gold doped p^+n junction and n-type MOS capacitor were measured experimentally and modeled theoretically for the case of majority-carrier defect charging. The gold acceptor atoms are initially charged with electrons at low temperatures, and during the heating cycle, excess electrons are released from the gold atoms. The thermally stimulated current response for this phase

is similar in both structures and has a distinctive peak-and-valley shape and an emission temperature about 220 K. During the steady-state phase, a current peak occurs in the MOS capacitance response. A physical model was developed and the influence of various parameters on the current and capacitance measurements was quantified. Various analytical schemes are described which allow rapid identification of the gold defect center and rapid computation of its density. A simple and inexpensive apparatus is described which is capable of heating rates as high as 10 K/s.

16364. Garvin, D., Hampson, R. F., Jr., **Evaluated numerical data for the SST and chlorofluorocarbon problems: A case study of how to help the engineer and the modellers,** (Proc. AGARD Conf., Washington, DC, Oct. 20-21, 1976), Paper in *AGARD Conference Preprint* **207** *on Advancement in Retrieval Technology as Related to Information Systems*, pp. 13-1—13-6 (National Aeronautics and Space Administration, Attn.: Reports Distribution and Storage Unit, Langley Field, VA 23365, 1976).

Key words: chemical kinetics; data center operation; information analysis center; photochemistry; stratospheric chemistry.

Mathematical simulations (models) of the stratosphere have been a primary tool in the analysis of potential pollution of the stratosphere from high-flying aircraft, rockets and the release of organic chlorine compounds at the surface of the earth. These models require large amounts of numerical data about the meteorology and chemistry. The chemical data comes from laboratory measurements and must be interpreted and made available to the user community in an understandable form and, preferably, as recommended values.

How chemical data were supplied to the Climatic Impact Assessment Program of the U.S. Department of Transportation is described here with emphasis on the role played by the Chemical Kinetics Information Center of the National Bureau of Standards. This included planning, identification of needed measurements and available measurements, determination of the needs of users, evaluation of data, interpretation of results for nonspecialists and distribution of tables of rate data. This type of role is suitable for an information analysis center in any large scale interdisciplinary program.

16365. Scheer, M. D., **Processes for converting coal to clean synthetic fuels and their dependence on catalytic materials,** (Proc. Ceramic Materials in High Temperature Gases on Materials Problems and Research Opportunities in Coal Conversion, Columbus, OH, Apr. 16-18, 1974), Paper in *Materials Problems and Research Opportunities in Coal Conversion* **2,** 300-312 (The Department of Metallurgical Engineering, The Ohio State University, Columbus, OH, 1975).

Key words: aromatic asphaltenes; caking; coal gasification; liquefaction processes.

Coal gasification is the chemical transformation of solid coal into a gas which can be ultimately reacted to produce methane which is free of sulfur compounds and contains little or no carbon monoxide and hydrogen. A typical process begins with the preparation of a coal powder whose particles are surface oxidized with air or oxygen so as to reduce its caking properties and hence prevent the plugging of reactor units.

Liquid fuels synthesized from coal will be needed to fulfill the requirements for these essential and conveniently transportable sources of energy. The technical requirements are numerous; coal must be liquefied; ash, S, N, and O removed; hydrogen produced from water and added to convert the aromatic asphaltenes to simpler aromatic which must then be cracked and reformed to produce acceptable gasolines.

16366. Odell, G. B., Schaffer, R., Simopoulos, A. P., Eds., **Phototherapy in the newborn: An overview,** 196 pages (Printing and Publishing Office, National Academy of Sciences, Washington, DC, 1974).

Key words: bilirubin; brain damage; hyperbilirubinemia; neonatal hyperbilirubinemia; phototherapy.

The book contains selected papers from a symposium held February 12-13, 1973 in Washington under the sponsorship of the Committee on Phototherapy of the Newborn, Assembly of Life Sciences, National Research Council. The papers concern the use of light as a therapeutic modality for hyperbilirubinemia in the newborn infant. Subjects considered are: The Radiometry of Phototherapy, Photooxidation, *In Vitro* Photooxidation Products of Bilirubin, The Photochemistry and Photometabolism of Bilirubin, Studies on the Mechanism of Phototherapy in the Congenitally Jaundiced Rat, Toxicity and Protein Binding of Biliverdin and Other Bile Pigments, Methods for Measurement of the Relative Saturation of Serum Albumin with Bilirubin in the Management of Neonatal Hyperbilirubinemia, Bilirubin-Dependent Brain Damage: Incidence and Indications for Treatment, Immediate and Long-Term Effects of Phototherapy on Preterm Infants, Effects of Light on Man, Circadian Rhythms, Important Considerations in the Clinical Management of Infants with Hyperbilirubinemia.

16367. Quindry, T. L., **Sound sensing units for intrusion alarm systems,** *NILECJ-STD-0308.00*, 22 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, July 1976).

Key words: alarm; audio alarm; burglar alarm; intrusion alarm; intrusion detector; sound sensing; standard.

This standard establishes performance criteria for sound sensing alarms intended for use in protective intrusion systems to monitor for attempts to enter a room or building. These devices cause the initiation of an alarm signal to a police panel, central station, or local audible alarm device. Included are requirements and test methods for performance, electrical properties and materials. The characteristics addressed are those which affect the reliability of the devices with emphasis on those performance characteristics which affect their false alarm susceptibility and its tamper resistance.

16368. Dobbyn, R. C., **Selection guide to hearing protectors for use on firing ranges,** *NILECJ-GUIDE-0101.00*, 24 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, Washington, DC, Apr. 1976).

Key words: earmuffs; earplugs; gunfire noise; hearing damage; hearing protectors; law enforcement equipment.

This guide discusses the hazard of gunfire-noise-induced hearing damage and the use of hearing protectors to guard against this hazard. Its purpose is to provide the shooter with an appreciation of the seriousness of the problem and a basis for the selection of a suitable hearing protector. Maximum permissible noise exposure levels are discussed in terms of the noise produced by firearms and the several damage-risk criteria which have been proposed. The guide concludes with a listing of currently-available hearing protectors and their noise attenuation properties.

16369. Robertson, E., Fechter, J. V., **Directory of security consultants,** *LESP-RPT-0309.00*, 64 pages (U.S. Department of Justice, Law Enforcement Assistance Administration, Na-

tional Institute of Law Enforcement and Criminal Justice, Washington, DC, Oct. 1975).

Key words: burglary; consultants; crimes of opportunity; directory, (security); investigations; law enforcement; resources; security; shoplifting; theft.

This directory presents brief summaries of the capabilities and past experience of security resources available to assist consumers in solving their security problems. Effective application of information provided by these resources should produce reduced crime rates. Individual listings present a brief digest of the background, past activities and specialization of each resource—based on information provided to this project. Presentations were separated into three categories: private consultants; consultants associated with colleges or universities; and specialized resources—associations, institutes, schools, authors, and publishers or film producers concentrating in the security field. Material is provided for information purposes only and does not constitute endorsement by the Federal government.

16370. Kilmer, R. D., Leasure, W. A., Jr., Corley, D. M., Mathews, D. E., Shoemaker, C. O., Jr., **Truck noise 1-D: Empirical model for predicting in-service truck tire noise levels,** *Report No. DOT-TST-76T-5*, 65 pages (Available from the National Technical Information Service, Springfield, VA 22161, July 1976).

Key words: acoustics; noise measurement; noise (sound); tire noise; transportation noise; truck.

SAE Recommended Practice J57—Sound Level of Highway Truck Tires—specifies a simple, practical noise certification test procedure for tires which results in a single-number rating—maximum A-weighted sound level—of the coastby sound level measured according to prescribed procedures. Such a rating by itself, however, does not allow prediction of in-service noise levels. This report discusses the basic assumptions and necessary input data for a DOT/NBS developed empirical model which utilizes the certification test results to predict in-service noise levels. The usefulness and expected accuracy of the predictive model are shown through a comparison of measured versus predicted maximum A-weighted sound levels for a variety of truck/tire combinations.

16371. Berger, H., Parker, W. L., Lapinski, N. P., Reimann, K. J., **Three-dimensional inspection by thermal-neutron laminagraphy,** *Trans. American Nuclear Society 1976 Annual Meeting, Toronto, Canada, June 14-18, 1976*, pp. 115-116 (1976).

Key words: complex object; laminagraphy; multiple-film; radiographic inspection; thermal neutrons; three-dimensional.

Multiple-film laminagraphy is demonstrated with thermal neutron radiographic inspection of a thick object. Radiographic views from several angular orientations are taken and superimposed to bring a desired image plane into focus. The angular views are obtained from the rotational movement of the object-detector assembly in contrast to the conventional translational source movement. The test object was a simulated EBR-II fast reactor fuel subassembly.

16372. Sengers, J. M. H. L., **Critical exponents at the turn of the century,** *Physica* **82A,** 319-351 (1976).

Key words: coexistence curves; critical exponents; fluid critical point; history; Kamerlingh Onnes collection; surface tension; Van der Waals collection; Verschaffelt.

The notion of a critical exponent was first used by Van der Waals in 1893 for describing the critical behavior of the surface tension. He also noticed in the early 1890's that experimental data on capillarity indicated a nonclassical value for the surface tension exponent. Verschaffelt found that this was due to the fact that the coexistence curve exponent beta was nonclassical. In 1900, he established precise nonclassical values for the exponents beta and delta. Even though from this time onwards the "cubic law" for fluid coexistence curves was accepted, the true implication of Verschaffelt's results, namely the failure of classical theory, was not appreciated. Some reasons for this lack of impact will be given.

16373. Boettinger, W. J., Burdette, H. E., Kuriyama, M., **Application of contrast conditions to dynamical images of immobile dislocations,** *Philos. Mag.* **34,** No. 1, 119-127 (1976).

Key words: contrast conditions; dynamical images; immobile dislocations; Lomer locks; sessile dislocations; x-ray dynamical diffraction; x-ray topography.

In x-ray topography, the Burgers vector of a dislocation is usually determined by finding those diffracting planes for which the image of the dislocation becomes invisible. The conditions $\mathbf{H}\cdot\mathbf{b}=0$ and $\mathbf{H}\cdot\mathbf{b}\times\mathbf{n}=0$ would then be applied to determine the Burgers vector. In this paper, these conditions of invisibility have been applied to a particular pattern of straight line images observed by Borrmann disruption in thick crystals ($\mu L > 15$) using many diffracting planes. It is found that the condition $\mathbf{H}\cdot\mathbf{b}=0$ alone is sufficient to determine that the images are caused by Lomer sessile edge dislocations. Furthermore, it is found that the condition $\mathbf{H}\cdot\mathbf{b}\times\mathbf{n}=0$ was not necessary to predict the invisibility of these images. This fact is attributed to the complexities of image formation by dynamical diffraction in imperfect crystals.

16374. Kulin, G., **Discussion of "sediment transport in smooth fixed bed channels" by P. Novak and C. Nalluri,** *J. Hydraul. Div. Proc. Am. Soc. Civ. Eng.* **102,** HY10, 1601-1602 (Oct. 1976).

Key words: grit; sand transport; sewage sand; sewer self-cleansing.

Design criteria for self-cleansing sewer flow are examined in the light of available experimental results on sand transport in open-channel flow in circular pipes.

16375. Block, S., Piermarini, G., **The diamond cell stimulates high-pressure research,** *Phys. Today*, pp. 44-47, 50-52, 54-55 (Sept. 1976).

Key words: diamond cell; electrical resistance; high pressure; nuclear decay; pressure calibrations; spectroscopy; x-ray diffraction.

This article is a general discussion of the diamond-anvil high pressure cell and includes a description of the instrument and the ruby fluorescence method of measuring pressure. It also discusses some of the important aspects in the development of the cell which ultimately led to the production of megabar pressures. A survey is made of what has been done already in this rapidly expanding area of research and includes a discussion of some new opportunities which show great potential.

16376. Hougen, J. T., **Methane symmetry operations,** Chapter 3 in *International Review of Science, Spectroscopy, Physical Chemistry Series Two*, A. D. Buckingham and D. A. Ramsay, Eds., **3,** 75-125 (Butterworth & Co., Ltd., Boston, MA, 1976).

Key words: energy levels; hyperfine interactions; methane; selection rules; symmetry species; tetrahedral.

This article provides a consistent, pedagogically convenient, and explicit treatment of symmetry properties in the CH_4 molecule, including a unified discussion of the permutation-inversion molecular symmetry group ideas of Longuet-Higgins and

the more traditional crystallographic point group symmetry ideas. It attempts initially to discuss symmetry properties associated with the spherical-top point group T_d by drawing on the more familiar symmetry properties associated with the D_{2d} symmetric-top subgroup of T_d. Although three different T_d symmetry classification schemes are widely used at present in the methane literature, strong arguments are presented favoring the present scheme. Illustrative references are included from the various schools of thought on theoretical matters, and from the different schools of recent experimental work on CH_4 vibrational, rotational, and hyperfine energy levels.

16377. Field, B. F., Hesterman, V. W., **Josephson junction based voltage standard,** *Proc. Fifth Cal Poly Measurement Science Conf., San Luis Obispo, CA, Dec. 5-6, 1975,* 5 pages (California Polytechnic State University, San Luis Obispo, CA 93407, 1975).

Key words: cryogenic; Josephson junction; standard cell; voltage reference.

An instrument is described that is designed to calibrate cadmium-sulfate (Weston) standard cells to an accuracy (3 σ) of 1 ppm or better. This instrument can replace the involved procedures, equipment and calibrations presently used to maintain a unit of voltage in many standards laboratories. A Josephson tunnel junction operating at cryogenic temperatures is used as a time-invariant reference for a special potentiometer which directly measures the emf of a standard cell. The instrument is easy to use and requires an infrequent frequency calibration.

16378. Cooper, J. W., **The single electron model in photoionization,** (Lecture delivered at the NATO Advanced Study Institute, Carry-le-Rouet, France, Aug. 31-Sept. 13, 1975), Paper in *Photoionization and Other Probes of Many-Electron Interactions*, F. J. Wuilleumier, Ed., pp. 31-47 (Plenum Press, Inc., New York, NY, 1975).

Key words: Hartree-Fock methods; oscillator strength; photoionization; single electron.

The theory of atomic photoionization is developed in a way to show the connections between single-electron and many-body theories.

16379. Langhoff, P. W., Corcoran, C. T., Sims, J. S., Weinhold, F., Glover, R. M., **Moment-theory investigations of photoabsorption and dispersion profiles in atoms and ions,** *Phys. Rev. A* **14,** No. 3, 1042-1056 (Sept. 1976).

Key words: atomic spectroscopy; dispersion; photoabsorption; refractive index.

Moment-theory methods for the construction of photoabsorption and dispersion profiles from associated dipole spectral moments are described and applied to simple atoms and ions. A previously devised (Stieltjes) moment approach, which provides convergent histogram approximations to absorption and dispersion profiles, is refined and extended to the use of arbitrarily large numbers of spectral moments, and an improved (Tchebycheff) moment approach is introduced which gives profiles that are continuous in the photoionization region and exhibit the δ-function-like behavior associated with discrete transitions at the appropriate frequencies. Recurrence relations for the polynomials orthogonal and quasiorthogonal with respect to the distributions are employed in solving the necessary moment problems involving large numbers of spectral moments. The methods are applied in illustrative calculations of absorption and dispersion profiles in one- and two-electron atoms and ions. In the case of one-electron atomic systems the necessary polynomial recurrence coefficients are obtained in closed form from the known spectral moments, allowing the construction of distributions which reproduce the known profiles with high accuracy, employing as many as 100 spectral moments. Variational calculations using large basis sets of square-integrable functions, including the special functions required to satisfy sum rules, provide accurate spectral moments for atomic helium and the negative hydrogen ion. A simple moment-extension procedure is devised to interpolate the associated recurrence coefficients to infinite order employing their known asymptotic values. The associated Stieltjes and Tchebycheff approximations to the absorption and dispersion profiles obtained in these cases are in excellent agreement with available measurements and previous accurate calculations employing discrete and continuum wave functions.

16380. Hall, J. L., Lee, S. A., **Interferometric real-time display of cw dye laser wavelength with sub-Doppler accuracy,** *Appl. Phys. Lett.* **29,** No. 6, 367-369 (Sept. 15, 1976).

Key words: interferometer, fringe counting; real-time display.

We describe an automatic fringe-counting interferometer with real-time wavelength readout for cw laser sources. Sub-Doppler absolute wavelength accuracy ($\sim 2\times10^{-7}$) is demonstrated with saturated absorption spectroscopy in neon.

16381. Kahler, R. L., Hillhouse, D. L., Anderson, W. E., **A simple overcurrent protection circuit for a high voltage laboratory,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 2, 161-162 (June 1976).

Key words: high voltage transformer protection; overcurrent; overcurrent protection; solid-state overcurrent protection circuit; transformer; transformer overcurrent protection.

A system for safeguarding a moderate power high-voltage laboratory against transformer overcurrents following insulation failures in test objects is described. It is simple, requiring the construction of only two solid-state control circuits and the modification of a commercially available solid-state contactor. It has been tested successfully with simulated breakdowns at up to 50-kV rms, 60 Hz with a 50-kVA load.

16382. Hartman, A. W., **A step height interferometer with one nanometer resolution,** *Opt. Eng.* **15,** No. 2, 180-183, 363 (Mar.-Apr. 1976).

Key words: interferometer; polarization; step height.

An interferometer is described for the measurement of thin film steps. The instrument is a double-pass polarization interferometer and has a resolution of one nanometer. It is self-contained and features simplicity in construction and operation. Measurements illustrating its performance are given.

16383. Brandon, D. G., Melmed, A. J., **FIM analysis of dislocation core structure,** *J. Micros.* **100,** Pt. 1, 7 pages (Jan. 1974).

Key words: core structure; dislocation core structure; FIM analysis.

A direct colour superposition technique has been used to study two dislocations in W, using He field-ion imaging at 77 K. Limitations due to instrumentation and field-ion microscopy are discussed. A single spiral and a double spiral on (112) W were each dissected, by field evaporation, through three successive atom layers, and apparent core shapes and dimensions were determined. The shapes were irregular with diameters of at most 0·5-2 nm for the single spiral and 0·5-1·7 nm for the double spiral. Observed displacements in the positions of the core regions may be associated with dislocation movement induced by the high electric field needed for the observations.

16384. Misakian, M., Hebner, R. E., Jr., **Kerr coefficients of polychlorinated biphenyls and chlorinated naphthalene,** *J. Appl. Phys.* **47,** No. 9, 4052-4055 (Sept. 1976).

Key words: Aroclor; chlorinated biphenyl; chlorinated naphthalene; electric field measurement; electro-optic; high voltage measurement; Kerr coefficients; Kerr effect; space charge.

The electro-optic Kerr coefficients of two polychlorinated biphenyls and chlorinated naphthalene have been measured to an accuracy of ±7 percent using a comparative technique. Physical properties of the fluids relevant to application in electro-optic devices are discussed.

16385. Goldberg, R. N., **Thermodynamics of hexokinase catalyzed reactions. II. Measurement and calculation of enthalpies of reaction as a function of magnesium ion concentration,** *Biophys. Chem.* **4,** 215-221 (1976).

Key words: adenosine 5′-triphosphate; biochemistry; coupled equilibrium; enzyme catalyzed reactions; glucose; heat measurement; hexokinase; magnesium; metabolic processes; microcalorimetry; thermochemistry; thermodynamics.

Enthalpies of phosphorylation of glucose by adenosine 5′-triphosphate have been measured as a function of concentrations of magnesium chloride in TRIS/TRIS·HCl buffer in the pH range 8.64 to 8.98. These measurements are compared with the results of calculations of these enthalpies that use a coupled equilibrium formalism with equilibrium data and enthalpy values selected from the literature. The experimental results span the range of magnesium ion concentrations 1×10^{-6} to 0.3 mol l^{-1} and show a total variation in the enthalpy of reaction of almost 10 kJ mol^{-1}, with the most exothermic reaction occurring at a magnesium ion concentration of 6.0×10^{-4} mol l^{-1}. The calculated enthalpies of reaction, except for the magnesium ion concentration range 4×10^{-6} to 5×10^{-4} mol l^{-1}, are, within estimated uncertainty intervals (0.8 to 10.2 kJ mol^{-1}), in agreement with the measured values.

16386. Cooper, J. W., Manson, S. T., **Photo-ionization in the soft x-ray range: Angular distributions of photoelectrons and interpretation in terms of subshell structure,** *Phys. Rev.* **177,** No. 1, 157-163 (Jan. 5, 1969).

Key words: angular distribution; photoabsorption; soft x rays; subshell structure.

The problem of determining the individual subshell contributions in atomic photoabsorption is discussed. The general form of the angular distribution of photoelectrons in the soft x-ray range for polarized incident photons is considered. Calculations of the subshell contributions within a central-field model and the angular distribution of electrons from these contributions for photoabsorption in Kr in the energy range 200-1500 eV are presented and found to show good agreement with the experimental results of the preceding paper.

16387. Swanson, K. R., Spijkerman, J. J., **Analysis of thin surface layers by Fe-57 Mössbauer backscattering spectrometry,** *J. Appl. Phys.* **41,** No. 7, 3155-3158 (June 1970).

Key words: backscattering measurements; Fe-57 Mössbauer spectra; Mössbauer spectra.

Fe-57 Mössbauer spectra for extremely thin surface layers (600-3000 Å) were obtained by detecting internal conversion electrons emitted after resonant absorption. The sample was placed inside a proportional counter specially designed for Mössbauer backscattering measurements. Helium-10% methane flowgas was used to detect the conversion electrons. It is estimated from the observed spectra that this technique can be used to obtain Mössbauer backscattering spectra for iron-containing surface layers 50-3000 Å thick. Backscattering spectra for thicker surface layers (0.2-0.5 mil) were obtained by merely changing to an argon-10% methane flow-gas mixture and counting the 6.3-keV internal conversion x rays rather than conversion electrons.

16388. Rutherford, W. M., Evans, J., Currie, L. A., **Isotopic enrichment and pulse shape discrimination for measurement of atmospheric Argon-37,** *Anal. Chem.* **48,** No. 3, 607-612 (Mar. 1976).

Key words: atmospheric mixing; atmospheric radioactivity; cosmic ray reactions; isotopic enrichment; ^{37}Ar.

High sensitivity measurements of cosmic-ray-produced ^{37}Ar from the Southern Hemisphere have been completed with the aid of thermal diffusion isotopic enrichment and low-level proportional counting with rise-time circuitry. Thermal diffusion proved to be an excellent means for increasing the very low natural specific activity of ^{37}Ar. Good enrichment factors (~70) were achieved in a period (~6 days) significantly less than the half-life (35.1 days) of ^{37}Ar. Results for Southern Hemisphere samples confirmed that the measurement process was sufficiently sensitive to quantitatively determine the natural, troposphere levels of ^{37}Ar, but they suggested the possibility of some contamination of the Southern Hemisphere ^{37}Ar from artificial sources.

16389. Shier, D. R., **Iterative methods for determining the k shortest paths in a network,** *Networks* **6,** No. 3, 205-229 (July 1976).

Key words: iterative methods; k best paths; linear equations; network algorithms; networks; shortest paths.

This paper presents and develops an algebraic structure for determining the k shortest paths from a given node to all other nodes of a network. Three new methods for calculating such k shortest path information are examined and compared. These methods are based on a fairly strong analogy which exists between the solution of such network problems and traditional techniques for solving linear equations. On the basis of both theoretical and computational evidence, one of the three methods is seen to offer an extremely effective procedure for finding the k shortest paths from a given node in a network.

16390. Lowe, T. C., **Computer security safeguards for privacy: The technical role of NBS,** *Bull. Am. Soc. Inf. Sci.* **3,** No. 1, 16-18 (Oct. 1976).

Key words: data confidentiality; data integrity; encryption; personal identification; privacy; record identification; risk analysis; security.

The paper describes selected projects under the NBS Computer Security Program that relate to the protection of personal privacy, and has been prepared in the format and style of the American Society for Information Sciences' *Bulletin.* This is ASIS' popular publication, as opposed to the more scholarly *Journal.*

16391. Johnson, C. E., Ogburn, F., **Hardness of heat treated electroless nickel,** *Surf. Technol.* **4,** 161-172 (1976).

Key words: auto-catalytic; auto-catalytic nickel; electroless; electroless nickel, hardness of; nickel; nickel-phosphorus alloy, wear of.

The hardness measurements of electroless nickel-phosphorus deposits are reported for compositions of 2.8-12.6 wt.% phosphorus. The hardness measurements were made on as-plated samples and after heat treatments covering a wide range of time and temperature.

As-plated hardness decreases with increasing phosphorus content up to 7-8 wt.% and then remains constant. After 9 hours at 200 °C, the hardness decreases with increasing phosphorus. Heat treatments at 400 °C and above result in hardnesses that depend on composition, time of heat treatment, and temperature of heat treatment. Qualitatively, the relationship is what one would expect for precipitation hardening.

16392. Heinrich, K. F. J., **Fluorescence excited by the continuum and the accuracy of electron probe microanalysis, (Extended Abstract),** *Proc. 10th Annual Conf. of the Microbeam Analysis Society, Las Vegas, NV, Aug. 11–15, 1975,* 7 pages (1975).

Key words: accuracy; continuum radiation; electron probe microanalysis; fluorescent excitation.

16393. Grabner, L., **Isoelectronic donor iodine and broad-band photoluminescence in TlBr,** *Phys. Rev. B* **14,** No. 6, 2514-2519 (Sept. 15, 1976).

Key words: isoelectronic systems; TlBr.

Two different experiments on nominally undoped crystals of TlBr (indirect band gap 2.670 eV) are reported: thermal quenching of the emission bands between 2 and 100 K, and the dependence of relative intensity of emission bands on exciting intensity, at 2 K. Both support unexpectedly small binding energies, of ~10 MeV, for electrons and holes to residual impurities. These emit broad (0.25 eV) structureless bands at 1.80, 2.20, and 2.43 eV, and are therefore expected to originate in tightly bound centers. Their origin is known only for the 2.20-eV band, which is due to the recombination of an exciton bound to the isolectronic impurity iodine. Thermal quenching of the emission bands shows two activation energies for the 2.20-eV band. These are identified with a binding energy of 37 MeV for the hole to the iodine, and 2 MeV for that of the electron to the system (iodine-hole). For the 2.43-eV band a single activation energy of 4 MeV is identified with the binding energy of an exciton to an unknown defect. Other isolectronic systems are compared with TlBr:I. Their possible connection with induced infrared absorption is suggested. Finally, the direct edge emission found in TlBr in the vicinity of 3.000 eV is discussed, and found to be anomalous in view of recent results showing its band gap to be indirect.

16394. Page, C. H., **What is weight?,** *Am. J. Phys.* **43,** No. 10, 920-921 (Oct. 1975).

Key words: force; kilogram; mass; pound; weight.

The common use of the term "weight" to denote either a mass or a force is discussed. It is shown that there is no acceptable *precise* definition of weight for moving objects. The conclusion is that a restriction on the use of "weight" to mean only a force that is measurable in certain specific situations is not justified, and, furthermore, would not only be unsuccessful but would hinder general acceptance of the metric system.

16395. Page, C. H., **Ambiguities in the use of unit names,** *Science* **179,** 873-875 (Mar. 2, 1973).

Key words: gyromagnetic ratio; measurement units; physical constants; SI units.

The SI concerns abstract idealized units; actual measurements are made in terms of laboratory standards. Reassignment of the value of a particular standard implies adjustments of published data, but the necessary adjustments are *not* deducible from the SI unit names attached to the data. Experimental determinations of physical constants should be reported in terms of the measurement units and standards actually used.

16396. Morrissey, B. W., Smith, L. E., Stromberg, R. R., Fenstermaker, C. A., **Ellipsometric investigation of the effect of potential on blood protein conformation and adsorbance,** *J. Colloid Interface Sci.* **56,** No. 3, 557-563 (Sept. 1976).

Key words: blood protein adsorption; conformation adsorbed proteins; ellipsometry; surface potential.

The possible relationship between the surface charge of an implant material and intravascular thrombosis has long been explored. In order to characterize the effect of potential on protein-surface interactions, ellipsometric measurements have been carried out *in situ* to determine the conformation and adsorbance of fibrinogen, γ-globulin, and serum albumin adsorbed on platinum and germanium for a range of imposed potentials.

On platinum at pH 7.4, fibrinogen, γ-globulin, and serum albumin all exhibited a reproducible "onset" potential, at which enhanced adsorption occurred. The adsorbance for all three proteins was unchanged from the rest potential value as the applied potential became more anodic until the onset potential was reached. Desorption, as a result of changes in applied potential, was not observed for any protein studied. The adsorbed conformation of all three proteins changed reversibly at moderately cathodic potentials as indicated, for example, by a sharp increase in extension at −0.2 V/SCE. The extension decreased as the imposed potential became progressively anodic. Germanium was found to be unsuitable for these ellipsometric studies due to etching of the surface by the 0.15 *M* NaCl immersion medium.

16397. Blevin, W. R., Steiner, B., **Redefinition of the candela and the lumen,** *Metrologia* **11,** 97-104 (1975).

Key words: candela; lumen; luminous flux; luminous intensity; photometry; SI basic unit.

It is proposed that the basic photometric unit be redefined so as to provide an exact numerical relationship between it and the SI unit of power, the watt, for a specified monochromatic radiation; and (2) that the unit of luminous intensity, the candela, be replaced as the basic unit by the unit of luminous flux, the lumen. It is claimed that the existing definitions are predominantly the product of early photometric practices that have been superseded. A closer link between photometry and spectroradiometry is now desirable. The proposals would enable photometric values to be derived from spectroradiometric data by exact computation, and would remove the need for a primary standard of light. They would not alter significantly the present magnitudes of the photometric units, nor change the existing relationship between photometry and visual perception. Because the proposed redefinitions are in terms of monochromatic rather than complex radiation, however, they would provide a more convenient basis for the future adoption of new spectral weighting procedures.

16398. Madey, T. E., Czyzewski, J. J., Yates, J. T., Jr., **Ion angular distributions in electron stimulated desorption: Oxygen and CO on W(111),** *Surf. Sci.* **57,** 580-590 (1976).

Key words: carbon monoxide; chemisorption; electron stimulated desorption; ion angular distribution; oxygen; tungsten.

The ion angular distributions resulting from electron stimulated desorption (ESD) of oxygen and carbon monoxide chemisorbed on a tungsten (111) crystal have been determined. The O^+ ions released during ESD of adsorbed oxygen exhibit three-fold symmetric angular distributions in orientational registry with the W(111) substrate. The CO^+ and O^+ ions released during ESD of a monolayer of CO are desorbed normal to the (111) surface. Models for both oxygen and CO adsorption are discussed. The data for CO are consistent with adsorption of CO in "standing up" carbonyl structures in the virgin and α-CO binding states.

16399. Layer, H. P., **High-resolution stepping motor drive,** *Rev. Sci. Instrum.* **47,** No. 4, 480-483 (Apr. 1976).

Key words: digital; drive; electronic; generator; motor; stepping.

A digital sine-cosine stepping motor drive has been constructed which decreases the rotational step size by a factor of 31. This system improves the smoothness and resettability of the motor and retains the conventional slew speed and accuracy.

16400. Johnson, D. R., Pearson, R., Jr., **Microwave region,** Chapter 4.3 in *Methods of Experimental Physics* **13, Spectroscopy,** Part B, D. Williams, Ed., pp. 102-133 (Academic Press, Inc., New York, NY, 1976).

Key words: chemical monitoring and analysis; double resonance; microwave instrumentation; microwave spectroscopy; radio astronomy; short-lived molecules.

The instrumentation and experimental techniques developed for the study of the microwave spectra of gases are critically reviewed, with emphasis on methods capable of wide applicability in the frequency range from 4 to 220 GHz where oscillators producing fundamental power are commercially available. A general purpose spectrometer, incorporating techniques widely used in spectroscopic laboratories, is described as a point of reference for defining the essential characteristics of the basic spectrometer components: a source of MW power, a modulator, an absorption cell, a detector, and a method for measuring frequency. As each is discussed the most widely used instrumentation is compared to selected alternative including new developments which show promise for future applications. Original designs for detector and frequency multiplier-mixer mounts and parallel plate absorption cells are given which, when appropriately scaled to the MW frequency, have been successfully used from 4 to 130 GHz. Spectrometers with special characteristics such as broad-banded scanning, high temperature applications, resonant cavity absorption cells, or submillimeter frequency capabilities are discussed. New developments in the submillimeter region have extended scanning microwave spectroscopy to 1.06 THz. The characteristics which make microwave spectroscopy unique—high sensitivity, specificity, and great versatility—are demonstrated by describing new applications to the study of short-lived molecules, chemical monitoring and radio astronomy.

16401. Fiori, C. E., Myklebust, R. L., Heinrich, K. F. J., Yakowitz, H., **FRAME B: An on-line correction procedure for quantitative electron probe microanalysis with a Si(Li) detector, (Extended Abstract),** *Proc. 10th Annual Conf. of the Microbeam Analysis Society, Las Vegas, NV, Aug. 11-15, 1975,* 8 pages (1975).

Key words: background correction; continuous radiation; electron microprobe correction procedure; energy-dispersive x-ray spectrometry; lithium-drifted silicon detector.

16402. Pella, P. A., **Generator for producing trace vapor concentrations of 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, and ethylene glycol dinitrate for calibrating explosives vapor detectors,** *Anal. Chem.* **48,** No. 11, 1632-1637 (Sept. 1976).

Key words: calibration device; dinitrotoluene; ethylene glycol dinitrate; explosives; generator; trinitrotoluene; vapors.

A vapor generator was constructed to produce known vapor concentrations of explosives such as 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, and ethylene glycol dinitrate below 1 ppb by volume for calibrating trace explosives vapor detectors. The system is temperature controlled which permits a wide range of equilibrium vapor concentrations to be generated. These vapor concentrations are diluted by single-stage, dynamic, gas blending to obtain concentrations as low as 0.05 ppb. A quantitative gas chromatographic procedure was developed to evaluate this system by measuring the output vapor concentrations. The systematic error was usually within 15 to 20 percent of the values expected for TNT, and within 30 percent for EGDN. The applicability of the system for calibration purposes is demonstrated by performance data obtained with three commercial trace explosives vapor detectors.

16403. Forester, D. W., Abbundi, R., Segnan, R., Sweger, D., **Magnetic hyperfine structure in amorphous $DyFe_2$,** (Proc. 20th Annual AIP Conf. on Magnetism and Magnetic Materials, San Francisco, CA, Dec. 3-6, 1974), Paper in *Magnetism and Magnetic Materials-1974,* C. D. Graham, Jr., G. H. Lander, and J. J. Rhyne, Eds., No. 24, 115-116 (American Institute of Physics, New York, NY, 1975).

Key words: amorphous; magnetization; metal; Mössbauer; ^{57}Fe; ^{161}Dy.

In this paper we summarize the results of a Mössbauer study of the amorphous rare earth-transition metal (RE-TM) alloy $DyFe_2$ in the magnetically ordered state. Both the ^{57}Fe and ^{161}Dy spectra were investigated as a function of temperature and reveal a broad, though measurable, distribution of Fe hyperfine fields (H_{eff}) and quadrupole splittings (QS). There is a distribution similar in magnitude for the Dy hyperfine fields but the observed quadrupole splittings are narrowly distributed. The temperature variation of the ^{161}Dy spectra indicates a large variation of local exchange splittings at the Dy sites. These results are discussed in terms of a model in which the Dy spins are more strongly coupled to their random-direction anisotropy axes than to the neighboring Fe spins (which also experience a weaker random-direction anisotropy).

16404. Hill, J. J., **A low frequency inductive ratio bridge for platinum resistance thermometry,** (Proc. 5th Symp. on Temperature, Its Measurement and Control in Science and Industry, Washington, DC, June 21-24, 1971), Paper in *Temperature, Its Measurement and Control in Science and Industry,* L. G. Rubin, A. C. Anderson, J. E. Janssen, and R. D. Cutkosky, Eds., **4,** Part 2, 1495-1499 (Instrument Society of America, Pittsburgh, PA, 1972).

Key words: ac bridges; bridges; platinum thermometers; resistance measurements; thermometry; two-stage transformers.

Most of the recently developed ac ratio transformer bridges for platinum resistance thermometry have operated at frequencies of the order of 400 Hz. Due to the fact that the resistance values of the thermometer and the comparison standard resistor at these frequencies may differ substantially from their dc values, doubt has been expressed regarding the correlation of such temperature measurements with those made using traditional dc methods. However, using two-stage transformer techniques, it is now possible to construct ratio transformers to operate at 20 or even 10 Hz with an accuracy of a few parts in 10^8 (equivalent to temperature intervals of few tens of micro degrees) and thus virtually eliminate this objection while still preserving all the advantages of ac methods. Nine-decade adjustable-ratio transformers have been built which are connected in a modified Kelvin Double Bridge circuit. The effective input impedance of the ratio arms is several megohms thus reducing the effect of the connecting leads to extremely small proportions. The paper also considers and discusses the relative advantages of most existing methods for platinum resistance thermometry, the limitations of comparison resistors and the philosophy behind possible future trends and developments.

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16405. Alperin, H. A., Cullen, J. R., Clark, A. E., **Magnetic properties of bulk amorphous Tb_xFe_{1-x},** (Proc. 21st Annual AIP Conf. on Magnetism and Magnetic Materials, Philadelphia, PA, Dec. 9-12, 1975), Paper in *Magnetism and Magnetic Materials-1975*, J. J. Becker, G. H. Lander, and J. J. Rhyne, Eds., No. 29, pp. 186-187 (American Institute of Physics, New York, NY, 1976).

Key words: amorphous Tb_xFe_{1-x}; Curie temperatures; magnetization measurement; neutron diffraction.

Magnetization measurements have been made on four bulk samples (compositions $x=0.018$, 0.118, 0.167 and 0.25) prepared by direct current rapid sputtering. Neutron diffraction measurements show these samples to be amorphous. All four samples are ferrimagnetic; however, the 17 percent sample is almost completely compensated at temperatures below 100K. With decreasing Tb-content, the Curie temperatures fall from a maximum of 405K for $x=0.25$ to the value of 245K for $x=0.018$. Anomalously large coercive fields and time dependent magnetizations are present at low temperatures.

16406. Helbig, V., Kelleher, D. E., Wiese, W. L., **Stark-broadening study of neutral nitrogen lines,** *Phys. Rev. A* **14,** No. 3, 1082-1093 (Sept. 1976).

Key words: nitrogen; plasma line boardening; spectral lines; Stark broadening; Stark shifts; Stark widths.

Extensive photoelectric measurements of the plasma-broadened line shapes of 42 neutral nitrogen lines have been carried out with a wall-stabilized arc. The arc current was varied from 20 to 100 A to achieve a variation in the axial electron density from about 5×10^{16} to 1.5×10^{17} cm^{-3}. Most observations were made end-on, and the arc was operated in pure nitrogen as well as argon with a small admixture of nitrogen to avoid self-absorption problems, which mainly arose with the red and near-infrared lines. The electron density was determined from the well-known Stark half-width of the hydrogen H_β line, for which purpose a trace of hydrogen was added to the plasma. Our principal results are as follows: (a) Good agreement with the recent theoretical work by Griem and coworkers has been obtained; (b) consistent with theoretical predictions, ion-broadening effects are not noticeable; (c) the Stark widths and shifts for different lines in a multiplet are identical within the experimental precision ($\approx3\%$) as predicted by the theory; and (d) measurements performed over a range of transitions involving different quantum states agree equally well with the theoretical data, indicating that the atomic-structure part of theory is very adequate.

16407. Hall, J. L., Magyar, J. A., **High resolution saturated absorption studies of methane and some methyl-halides,** Chapter 5 in *Topics in Applied Physics* **13,** High-Resolution Laser Spectroscopy, K. Shimoda, Ed., pp. 77–86, 86B (Springer-Verlag, New York, NY, 1976).

Key words: high resolution spectroscopy; methyl halides; optical heterodyne spectroscopy; quadrupole hyperfine interactions; saturated absorption spectroscopy.

We apply the techniques of high resolution saturated absorption spectroscopy to a number of methyl halide transitions near 3.39 μm. Wavenumbers and assignments are given for most lines. A "ladder" of frequency intervals was established with optical heterodyne techniques. Hyperfine structures due to electric quadrupole interactions was carefully studied for one transition in each of the three heavier methyl halides. This analysis gave the shift in the value eqQ due to vibrational excitation as well as information about the magnetic coupling energy. Finally a spectrum of CH_4 is presented which displays a resolving power of 5×10^{10}. This value is believed to be the highest yet employed in coherent spectroscopy.

16408. Brown, P. W., Clifton, J. R., Frohnsdorff, G., Berger, R. L., **The utilization of industrial by-products in blended cements,** (Proc. 5th Mineral Waste Utilization Symposium, Chicago, IL, Apr. 13-14, 1976), Paper in *Proceedings of the Fifth Mineral Waste Utilization Symp.*, pp. 278-284 (ITT Research Institute, Chicago, IL, 1976).

Key words: blast furnace slag; blended cement; fly ash; materials and energy conservation.

Approximately 85 million tons of portland cement are produced annually in the United States. However, less than one million tons of blended cement containing suitable waste or by-product materials, such as fly ash or blast furnace slag, are produced. In view of the potential for by-product utilization and raw materials and energy conservation, the advantages of increased use of blended cement should be considered. The potential for blended cement production and utilization and the advantages and limitations of utilization are discussed. The limitations imposed on the use of blended cements by standards and other factors are discussed. The technical benefits from the use of blended cements are considered.

16409. Brinckman, F. E., Iverson, W. P., Blair, W., **Approaches to the study of microbial transformations of metals,** *Proc. 3d Int. Biodegradation Symp., Kingston, RI, Aug. 17-23, 1975*, pp. 919–936 (Applied Science Publ. Ltd., London, England, 1976).

Key words: detection; flameless atomic spectrophotometry; gas chromatography; graphite furnace; methylation of metals; microbial transformation; speciation; volatile metal compounds.

An approach to the study of microbial transformations of metals existing in trace amounts in the environment is based primarily on the detection and speciation of volatile forms of these metals. Simple qualitative means for surveying the potential of microorganisms for volatilizing metals are described. Identification of transport agents has been accomplished primarily through the use of flameless atomic spectrophotometry coupled with gas chromatography. This technique permits chracterization of volatile metals and organometallic compounds in the nanogram range so that microbial transformations of metals at environmental levels may by monitored. The abiotic transfer of methyl groups from biologically methylated metals to Hg(II) provides a useful tool for the speciation of volatile metal forms suspected of being methylated.

16410. Yakowitz, H., **Present status of quantitative electron probe microanalysis,** *Proc. 6th European Congress on Electron Microscopy, Jerusalem, Israel, Sept. 1976*, pp. 37-40 (Tal International Publishing Co., Jerusalem, Israel, 1976).

Key words: electron probe microanalysis; Monte Carlo calculations; particulates; quantitative analysis; thin films; x rays.

All procedures for performing quantitative x-ray microanalysis require use of a standard of known composition. The analyst measures the relative x-ray intensity ratio between the elements of interest in the specimen and the same element in the standard. Both specimen and standard are measured under identical experimental conditions. The measured relative intensity ratio, often called k, must be accurately determined or else any quantitative analysis scheme will result in the same inaccuracy. Factors which can contribute to inaccuracies in k include the Poisson statistics of the x-ray emission process, x-ray detector coincidence loss (dead time) effects, and background noise arising from continuum radiation. Once the k values have been obtained, they must be corrected for several effects including: the differences in electron scattering and retardation in the specimen

and standard, i.e., the so-called atomic number effect, absorption of x-rays generated within the specimen along the direction of the x-ray detector, fluorescence effects and continuum fluorescence effects.

16411. Simmons, J. A., **Microscopic aspects of residual stresses,** *Proc. Workshop on Nondestructive evaluation of Residual Stress, San Antonio, TX, Aug. 13-14, 1975,* pp. 11-17 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, OH, 1976).

Key words: dislocation theory; imperfect continua; internal stress; nondestructive evaluation; residual stress.

This lecture on Microscopic Aspects of Residual Stresses was given to the Air Force Materials Laboratory Workshop on Nondestructive Evaluation of Residual Stress. Residual stress and the more general concept of internal stress are defined and their theory developed using the modern methods of elasticity in imperfect continua.

16412. MacGregor, J. G., Breen, J. E., Pfrang, E. O., **Design of slender concrete columns,** *ACI J.*, pp. 6-28 (Jan. 1970).

Key words: bending moments; building codes; column (supports); frames; long columns; reinforced concrete; slenderness ratio; strength; structural analysis; structural design; ultimate strength.

Offers a proposal for revising the slender column design procedures of the 1963 ACI Code. Proposes the use of a rational second-order structural analysis wherever possible or practical. In place of such an analysis, an approximate design method based on a moment magnifier principle and similar to the procedure used under the AISC Specifications is proposed. An outline of the normal range of variables in column design and a lower limit of applicability is proposed which will eliminate over 90 percent of columns in braced frames and almost half of columns in unbraced frames from consideration as slender columns. Through a series of comparisons with analytical and test results, the accuracy of the approximate design procedure is established.

16413. Lind, M. A., Zalewski, E. F., **Silicon photodetector instabilities in the uv,** *Appl. Opt.* **15,** No. 6, 1377-1378 (June 1976).

Key words: detector; photodiode; silicon; ultraviolet; uniformity of response.

Recent measurements of a group of photovoltaic silicon detectors has revealed instabilities that occur in some silicon photodiodes. We discuss two such instabilities which manifest themselves as an increase in the spatial nonuniformity in the uv and an increase in the spectral responsivity after high level uv irradiation. Typical measurements of two types of silicon detectors are presented.

16414.. Bingham, C. D., Yolken, H. T., Reed, W. P., **Nondestructive assay measurements can be traceable,** *Nucl. Mater. Manage.* **V,** No. II, 32-35 (Summer 1976).

Key words: calibration; measurement; nondestructive assay; nuclear; safeguards; traceability.

The use of nondestructive assay (NDA) techniques for the analysis of Special Nuclear Materials is one of the keystones in the development of safeguards technology. Currently this effort to use NDA is being frustrated because of a lack of "demonstratable traceability." Presented here is a discussion of what traceability means and how it can be achieved. Specifically, traceability means far more than having a series of calibration standards for each individual NDA technique. It means defining the limits of uncertainty for both random and systematic error components of a set of measurements (i.e., precision and accuracy). Realizing this, an approach to these evaluations is suggested. In addition, the authors emphasize that the availability of standards is not holding back the use of NDA.

The use of NDA is actually limited by the poor accuracy (possible systematic error) of many methods and the availability of real calibration standards would only tend to accentuate this point.

Finally, the suggestion is made that calibration standards will only be available when the demonstrated need is limited to a finite number of sets.

16415. Lucatorto, T. B., McIlrath, T. J., **Efficient laser production of a Na^+ ground-state plasma column: Absorption spectroscopy and photoionization measurement of Na^+,** *Phys. Rev. Lett.* **37,** No. 7, 428-431 (Aug. 16, 1976).

Key words: far ultraviolet spectroscopy; ion absorption spectrum; ion photoionization; laser ionization; photoionization resonances; sodium.

We report the first observation of ionization of dense Na vapor by laser radiation. A 1-MW pulsed laser at 589.6 nm produced almost complete ionization of a 10-torr-cm column of Na. Measurements of the Na^+ photoionization cross section, the neonlike series $2s^22p^6 \rightarrow 2s^22p^5ns$ and nd, and several autoionizing resonances of the type $2s^22p^6 \rightarrow 2s2p^6np$ were obtained using a spark source to provide the continuum background for absorption spectroscopy of the ion.

16416. Post, M. A., Iverson, W. P., Campbell, P. G., **Evaluating non-mercurial fungicides,** *Mod. Paint Coat.* **66,** No. 9, 31-38 (Sept. 1976).

Key words: accelerated testing; alkyd paints; environmental chamber; exterior exposure; latex paints; nonmercurial fungicides.

Nonmercurial fungicides were evaluated for effectiveness in an exterior acrylic latex and in an exterior long oil alkyd paint. Exterior exposure tests were of six months, one year and two years duration at the National Bureau of Standards exposure site. Exterior exposure tests were also carried out at the U.S. Naval Station, Roosevelt Roads, Puerto Rico. Accelerated fungus exposure testing was performed for four and eight weeks in an environmental chamber (a) without prior exterior exposure, (b) after six months, one year and two years exterior exposure, and (c) after exposure in a xenon arc accelerated weathering apparatus. Of the eight nonmercurial fungicides tested for latex paint protection, only one afforded complete fungicidal protection after two years exterior exposure. Two of the six nonmercurial fungicides tested for alkyd paint protection were excellent. One was superior and the other equal to the mercurial fungicide. The mercurial fungicide afforded much better protection for alkyd than latex paints.

16417. Grabec, I., Peterlin, A., **Acoustic emission of a crazing polymer,** *J. Polym. Sci.: Polym. Phys. Edition* **14,** 651-661 (1976).

Key words: acoustic emission; amorphous polymer; crazing; fatigue; Kaiser's effect.

The acoustic emission from a crazing polyvinyltoluene in a tensile and bending experiment is described. Acoustic emission appears as a series of bursts which most likely correspond to the initiation and growth of crazes. The emission intensity is characterized by acoustic activity (pulse rate) measured by the ringdown technique. The average activity increases with strain. During repeated loading the acoustic activity shows a measurable intensity and significant rise only beyond the maximum strain of

the former runs. This is equivalent to Kaiser's effect in metals. Acoustic emission during the creep experiment occurs in three characteristic periods. They are characterized as the relaxation, fatigue, and breakdown periods. Visual observations indicate that the relaxation period corresponds to the initiation, and the fatigue period to the growth of crazes. In the breakdown period a macroscopic crack develops and the sample fails.

16418. Penn, D. R., **Comment on "Field emission as a probe of the surface density of states",** *Phys. Rev. B* **14,** No. 2, 849-853 (July 15, 1976).

Key words: field emission; surface density of states; transfer Hamiltonian.

It is shown that the primary contribution to the field-emission current comes from electrons with *total* momentum equal to zero in a direction parallel to the metal surface and that the field-emission current measures the density of states at a point several angstroms from the metal surface. An explicit expression is derived for the error made in using the transfer-Hamiltonian technique to calculate the tunneling probability of an electron through a one-dimensional barrier, and it is pointed out that the error is small in the case of field emission.

16419. Plummer, E. W., Waclawski, B. J., Vorburger, T. V., Kuyatt, C. E., **Photoelectron spectra of adsorbed species on tungsten,** *Prog. Surf. Sci.* **7,** 149-182 (1976).

Key words: adsorption; carbon; carbon monoxide; chemical bonding; chemisorption; density dependent transitions; desorption; dissociative adsorption; electronic states; hydrogen; monolayers; nitrogen; oxygen; photoelectron spectra; relaxation energy; surfaces; tungsten; ultraviolet photoemission; valence band; virgin states; α states; β states.

Photoelectron spectra from W(100) and W(110) for $h\omega = 21.22$ and 16.85 eV were studied as a function of controlled exposure to H_2, N_2, and CO at room temperature, and with subsequent heating. The spectra revealed density-dependent conversions of the β-states of adsorbed hydrogen and carbon monoxide. The α and virgin states of CO appear to be molecular with the α state sequentially filling on top of the β-state. The ordered β-state of CO on W(100) is shown to be dissociatively adsorbed. For W(100) photoelectron spectra for initial states overlapping the tungsten band are very similar for nitrogen and carbon adsorbed in the geometrical configuration indicated by a c(2 $\times$ 2) LEED pattern. In contrast, hydrogen and oxygen adsorbed on W(100) in a c(2 $\times$ 2) configuration produce different spectra, leading to the speculation that nitrogen and carbon may adsorb in the same site.

16420. Kaufman, V., Sugar, J., **Wavelengths, classifications, and ionization energies in the isoelectronic sequences from Yb II and Yb III through Bi XV and Bi XVI,** *J. Opt. Soc. Am.* **66,** No. 10, 1019-1025 (Oct. 1976).

Key words: bismuth; gold; hafnium; ionization energies; iridium; lead; lutetium; mercury; osmium; platinum; rhenium; tantalum; thallium; tungsten; wavelengths; ytterbium.

Spectral observations are reported for transitions to the ground term and first excited term of the one-electron configurations in the $4f^{14}5p^6nl$ isoelectronic sequence from Yb II through Bi XV. Resonance lines are reported for the isoelectronic sequence Yb III through Bi XVI in which the ground state is $4f^{14}5p^6\ {}^1S_0$ and the upper levels are the $J=1$ levels of the $4f^{13}5p^6nd$, $4f^{14}5p^5nd$, and $4f^{14}5p^5ns$ configurations. The wavelengths fall in the range 70-3700 Å. The spectra were produced by means of sliding and triggered spark discharges and photographed with 10.7 m normal and grazing incidence spectrographs. The data in the Yb III sequence demonstrate the crossing of binding energies of the $4f$ and $5p$ shells at W VII. Rydberg series terms were found in a sufficient number of cases to provide extrapolation curves through Bi XV and Bi XVI. These data enabled us to calculate ionization energies for each of these ions with an uncertainty of ~1 percent or better.

16421. Gadzuk, J. W., **Screening energies in photoelectron spectroscopy of localized electron levels,** *Phys. Rev. B* **14,** No. 6, 2267-2280 (Sept. 15, 1976).

Key words: adsorption; electron gas; photoemission; relaxation energy.

Screening or polarization energies (often called "extra-atomic relaxation energies") associated with localized-hole creation in photoelectron spectroscopy in or on metals have been calculated. Following the procedure of Hedin and Lundqvist, the screening energy is written in terms of an effective matrix element of a nonlocal random-phase-approximation self-energy between wave functions of the localized-hole state. The relevance of spatial extent of the hole, electron-gas dielectric properties, chemical-bonding effects, and surface effects are examined. Calculations for 1 s core and bonding H_2 orbital holes in atoms or molecules which are embedded in and adsorbed on electron-gas surfaces are presented. The interplay between orbital size and host interelectron spacing (as manifested in screening lengths) is emphasized. The relationship between screening energies and classical image potentials in photoelectron spectroscopy of adsorbed atoms and molecules is established. Finally, interpretations of observed photoelectron spectra are discussed in terms of binding energies and relaxation, chemical, and "dipole" potential shifts, and the problem of "proper" referencing is addressed.

16422. Siedle, A. R., Hertz, H. S., **Vaporization of (SN)x and TTF-TCNQ,** *Mater. Res. Bull.* **11,** No. 9, 1185-1189 (1976).

Key words: chemical ionization mass spectrometry; mass spectrometry; sulfur nitride; tetracyanoquinodimethane; tetrasulfur tetranitride; tetrathiafulvalene; vaporization.

The vaporization of (SN)x was studied by electron impact and chemical ionization mass spectrometry. Comparison of the spectra with those of S_4N_4 suggests that vaporization generates an unstable, acyclic S_4N_4 which subsequently fragments to a cyclic $S_3N_3^+$ and SN^+ ion in the mass spectrometer. Mass spectrometry may be used to analyze (SN)x for S_8 and cage S_4N_4. Vaporization of TTF-TCNQ produced the component donor and acceptor molecules.

16423. Hertz, H. S., May, W. E., Chesler, S. N., Gump, B. H., **Petroleum analysis: Methodology for quantitative and qualitative assessment of oil spill,** *Environ. Sci. Technol.* **10,** No. 9, 900-903 (Sept. 1976).

Key words: gas chromatography; liquid chromatography; oil spill; petroleum; quantitation.

An integrated chromatographic technique for petroleum analysis compatible with long-term studies of oil spills is presented. Dynamic headspace sampling and the complementary analytical techniques of gas chromatography and coupled-column liquid chromatography are utilized for quantitation of petroleum containing samples. Gas chromatography-mass spectrometry is employed for identification of individual components in these samples. Analytical data obtained from a major oil spill are presented and discussed.

16424. Buehler, M. G., Thurber, W. R., **A planar four-probe test structure for measuring bulk resistivity,** *IEEE Trans. Electron Devices ED-23,* No. 8, 968-974 (Aug. 1976).

Key words: bulk resistivity; collector resistivity; four-probe; planar test structure; resistivity; semiconductor characterization; semiconductor device; silicon; square array.

A small planar four-probe test structure for measuring the bulk or collector resistivity of silicon wafers was designed and fabricated with a bipolar transistor process. Analogous to a mechanical square array four-point probe, the planar four-probe structure consists of a large-area base diffusion which is broken at four points through which contact is made to the undiffused collector material. A probe spacing of 2.25 mil (57.2 μm) allows the resistivity of the silicon wafer to be measured with good spatial resolution. A correction factor was derived to obtain the true resistivity from measurements on a wafer with finite thickness and a conducting backside, and it is presented along with the correction factors for other cases. The test device was fabricated in silicon wafers whose resistivities ranged from 0.013 Ω·cm to 12 Ω·cm in *n*-type material and from 0.7 Ω·cm to 30 Ω·cm in *p*-type material. Planar four-probe resistivity values are compared with mechanical four-probe values taken on the same wafers before fabrication, and the results are generally in agreement within ±3 percent.

16425. Reader, J., Acquista, N., **$4s^24p^4$-$4s4p^5$ transitions in Zr VII, Nb VIII, and Mo IX,** *J. Opt. Soc. Am.* **66,** No. 9, 896-899 (Sept. 1976).

Key words: molybdenum; niobium; spectra; ultraviolet; wavelength; zirconium.

Spectra of ionized Zr, Nb, and Mo have been observed in sliding spark discharges at peak currents up to 4000 A on the 10.7 m normal and grazing incidence spectrographs at NBS. From these observations the group of $4s^24p^4$-$4s4p^5$ transitions in Zr VII, Nb VIII, and Mo IX have been identified and measured. The energy parameters obtained from least-squares fits to the resultant energy levels are compared with Hartree-Fock calculations.

16426. Cezairliyan, A., McClure, J. L., Coslovi, L., Righini, F., Rosso, A., **Radiance temperature of tantalum at its melting point,** *High Temp.—High Pressures* **8,** 103-111 (1976).

Key words: emittance; high-speed measurements; high temperature; melting point; pyrometry; radiance temperature; tantalum.

Radiance temperature (at two wavelengths, 653 and 995 nm) of tantalum at its melting point was measured with the use of a subsecond-duration pulse heating technique. Specimens in the form of strips with initially different surface roughnesses were used. The results do not indicate any dependence of radiance temperature (at the melting point) on initial surface or system operational conditions. The average radiance temperature at the melting point of tantalum is 2846 K at 653 nm and 2620 K at 995 nm, with a standard deviation of 1 K at 653 nm and 0.4 K at 995 nm. The total inaccuracy in radiance temperature is estimated to be not more than ±8 K.

16427. Morrissey, B. W., Fenstermaker, C. A., **Conformation of adsorbed γ-globulin and β-lactoglobulin. Effect of surface concentration,** *Trans. Am. Soc. Artif. Intern. Organs* **XXII,** 278-283 (1976).

Key words: conformation adsorbed proteins; ellipsometry; infrared bound fraction; protein adsorption.

The adsorption of clotting factors and proteins on the surface of a synthetic implant can modify both their biological activity and the subsequent interaction of formed cellular elements with the surface. In particular, γ-globulin has been implicated in specific biochemical reactions resulting in platelet adhesion. Infrared bound fraction and ellipsometric measurements have been carried out *in situ* to determine the conformation of adsorbed γ-globulin and β-lactoglobulin as a function of surface concentration.

The fraction of adsorbed carbonyl groups of γ-globulin and β-lactoglobulin decreases significantly as the amount adsorbed increases. Ellipsometric measurements of the extension of adsorbed γ-globulin show that as the number of surface attachments decreases, the thickness of the adsorbed protein film increases. Studies with a cross-linked γ-globulin preparation indicate that the native conformation in solution corresponds to an adsorbed conformaton intermediate between those found at the extremes of high and low surface concentration.

These results indicate that adsorbed γ-globulin is rather pliant and that the adsorbed conformation of proteins which are present should be taken into account when describing platelet-surface interactions.

16428. Goldberg, R. N., **Microcalorimetric determination of glucose in reference samples of serum,** *Clin. Chem.* **22,** No. 10, 1685-1691 (1976).

Key words: hexokinase; intermethod comparison.

I report a detailed series of microcalorimetric measurement of glucose concentrations in five reference samples of serum. The method utilized (a) calibration in the actual medium of analysis and (b) a correction for interferences owing to the nonspecificity of the enzyme hexokinase. The microcalorimetric results are compared with the tentative results of analyses obtained by the spectrophotometric hexokinase/glucose-6-phosphate dehydrogenase method and by isotope-dilution mass spectrometry. In most cases, the microcalorimetric results appear to be in agreement with the results obtained by these latter two methods. A discussion of the basis of the microcalorimetric measurements is presented.

16429. Johnson, D. R., Suenram, R. D., Lafferty, W. J., **Laboratory microwave spectrum of cyanamide,** *Astrophys. J.* **208,** No. 1, 245-252 (Aug. 15, 1976).

Key words: interstellar molecules; interstellar laboratory spectra; interstellar line identifications; interstellar molecular processes; interstellar transition probabilities.

Laboratory test frequencies have been obtained for rotational transitions of the cyanamide molecule (NH_2CN) in the ground state and the lowest vibrational (NH_2 inversion) state, extending the measured spectrum of the molecule to 120 GHz. Perturbations resulting from Coriolis-type interactions between the ground and the lowest vibrational state cause many of the observed transitions to deviate significantly from the predictions of a conventional centrifugal distortion-corrected rigid rotor model. Absolute energies and Einstein *A* coefficients are presented for all measured transitions up to $J = 8$ for both states considered.

16430. Cehelnik, E. D., Mielenz, K. D., **Quantum counter photodetectors: A new design,** *Appl. Opt.* **15,** No. 9, 2259-2263 (Sept. 1976).

Key words: emission anisotropy; fluorescence; photodetectors; polarization; quantum counters; rhodamine B chloride; spectrofluorimetry; total internal reflection.

A new design for quantum counter cells is described that uses total internal reflection to minimize depth-of-penetration and polarization effects. This new cell is compared to a standard 1-cm thick quantum counter cylindrical cell. Solutions of 5 g/liter of rhodamine B chloride in ethylene glycol were used in both cells. The fluorescence emission from the cell was found to be

significantly less polarized and also less dependent on excitation wavelength.

16431. Seltzer, S. M., **The response of scintillation detectors to internally induced radioactivity,** *Nucl. Instrum. Methods* **127,** 293-304 (1975).

Key words: background; gamma-ray astronomy; induced radioactivity; Monte Carlo calculation; response; scintillation detector.

Pulse-height distributions produced in NaI and CsI detectors by the decay of certain internally distributed radionuclides have been calculated using a Monte Carlo method. The method traces the possible decays of a radioactive atom, taking into account $\beta^{\pm}$-emission, electron capture, gamma-ray emission, internal-conversion-electron emission, and x-ray or Auger-electron emission following the creation of atomic K-shell vacancies. The scattering, absorption, and escape of gamma-rays, annihilation quanta, and x rays are included. Results are presented for the radioisotopes ^{22}Na, ^{124}I, ^{124}Sb, ^{125}Sb, ^{123m}Te, and ^{125m}Te to indicate the characteristic features of the pulse-height distributions.

16432. Sharp, K. G., Li, S., Johannesen, R. B., **Perfluoro(alkylsilanes). 3. Fluorine-fluorine coupling constants in perfluoro(alkylsilanes) and related molecules,** *Inorg. Chem. Notes* **15,** No. 9, 2295-2297 (1976).

Key words: coupling constants; fluorine; fluoroalkylsilanes; NMR; relative signs; silicon.

^{19}F NMR spectrometric analyses—including relative signs for most F-F coupling constants have been carried out for the perfluoro(alkylsilanes) $CF_3CF_2SiF_3$, $CF_3SiF_2SiF_3$, $CF_3CF_2CF_2SiF_3$, and $SiF_3CF_2SiF_3$. The latter three compounds have not been previously reported. The signs of J_{FF} values can be put on an absolute basis via self-consistent correlations between the above molecules and related polyfluoroalkanes or alkylsilanes, including the series CF_3CF_2X, CF_2SiF_2X, and SiF_3SiF_3X where X = halogen. An effect not previously recognized is that on substitution of Si for C in molecular fragments of the type FCCF or FCSiF the three bond F-F coupling invariably increases by ca. +6 to +10 Hz in an algebraic sense. Theoretical implications of this effect are discussed.

16433. Pallett, D. S., Pierce, E. T., Toth, D. D., **A small-scale multi-purpose reverberation room,** *Appl. Acoust.* **9,** 287-302 (1976).

Key words: acoustic modelling; acoustics; impact noise; noise; reverberation rooms; room acoustics; sound power.

A one-fourth scale model of the large (425 m^3) National Bureau of Standards reverberation room is described. This facility was constructed to carry out acoustical research at relatively low cost in a frequency range two octaves higher than that used in the larger facility. Initial experimental measurements carried out in this facility concern sound power emitted by small sources. The pure tone qualification procedure specified in American National Standard S1.21-1972 "Methods for the Determination of Sound Power Levels of Small Sources in Reverberation Rooms" was carried out using computer control of the experiment. This standard is of particular interest to the international acoustical community since it is technically equivalent to ISO Documents DIS 3741 and DIS 3742. The effect of increased low frequency absorption upon room qualification was tested in the model room. Future research plans to make use of the small-scale reverberation rooms are described.

16434. Snyder, L. E., Hollis, J. M., Ulich, B. L., Lovas, F. J., Johnson, D. R., Buhl, D., **Radio detection of interstellar sulfur dioxide,** *Astrophys. J.* **198,** No. 2, L81-L84 (June 1, 1975).

Key words: interstellar; microwave spectra; molecules; Orion; radio astronomy; sulfur dioxide.

Interstellar sulfur dioxide (SO_2) has been detected in emission from the direction of the Orion Nebula molecular cloud and from Sgr B2. SO_2 is the heaviest interstellar molecule detected to date, and the only nonlinear triatomic molecule which does not contain hydrogen. The remarkable Orion emission profiles suggest that two components are supporting the SO_2 emission: a dense circumstellar-type envelope, which may be in maser emission, and a warm galactic cloud component.

16435. Petree, B., Humphreys, J. C., Lamperti, P. J., Loftus, T. P., Weaver, J. T., **Comparison of cobalt-60 exposure determinations by calorimetry and by ionization chamber techniques,** *Metrologia* **11,** 11-15 (1975).

Key words: calorimetry; cobalt-60; ionization chamber.

The exposure rate computed from calorimeter power measurements is compared to the exposure rate of the same source (1-Ci cobalt-60) determined by means of a graphite cavity ionization chamber. A difference of 0.38 percent was found and is not considered significant compared to the estimated systematic uncertainty (1.3%).

16436. Mangum, B. W., Utton, D. B., **Antiferromagnetic ordering in $ErPO_4$,** (Proc. 20th AIP Conf. on Magnetism and Magnetic Materials, San Francisco, CA, Dec. 3-6, 1974), Paper in *Magnetism and Magnetic Materials*, C. D. Graham, Jr., G. H. Lander, and J. J. Rhyne, Eds., No. 24, pp. 65-66 (American Institute of Physics, New York, NY, 1975).

Key words: antiferromagnetic transition; antiferromagnetism; dipolar interactions; $ErPO_4$; magnetic phase diagram; Néel temperature; spin-flop.

The magnetic susceptibility and dM/dB as a function of field have been measured for $ErPO_4$ from 25 mK to 4.2 K. They show that $ErPO_4$ orders antiferromagnetically with $T_N = 100 \pm 2$ mK with the spins along the tetragonal a-axes. The magnetic phase diagram is presented which includes a spin-flop phase in the basal plane. It is proposed that dipolar interactions may be responsible for the magnetic ordering.

16437. Shumaker, J. B., **Light emitting diode calibrations at NBS,** *Proc. 8th Session Comité Consultatif de Photométrie et Radiométrie, Sèvres, France, Sept. 3-5, 1975*, pp. 95-99 (Bureau International des Poids et Mesures, Pavillon de Breteuil, Sèvres, France, 1976).

Key words: calibration; light emitting diode; spectral irradiance.

A very brief report is given of some aspects of spectral irradiance calibrations of red LEDs at NBS. A typical spectral distribution is given and the treatment of temperature effects is discussed.

16438. Marlowe, D. E., **National measurement study—Microstudy force,** *NCSL Newslett.* **14,** No. 1, 44-45 (Mar. 1974).

Key words: force; NMS.

A brief summary of the National Measurement System Micro-Study of Force is presented.

16439. Davis, R. M., **Implications of privacy legislation on the use of computer technology in business,** *Jurimetrics J.* **17,** No. 1, 95-110 (Fall 1976).

Key words: computer security; information handling; privacy; safeguards for security and privacy; technology for security and privacy.

The National Bureau of Standards has been charged with responsibility for developing guidelines and standards for government compliance with legislation to protect individual privacy. NBS has identified emerging problems in security and privacy and the need for technological developments to provide solutions. Safeguards for security and privacy are not identical. The large number of record systems processing personal records in both the public and private sectors points up the magnitude of the problem of retrofitting these systems for security and privacy safeguards. In many cases, sophisticated systems are not required, and good information practices will be sufficient to meet the requirements. The safeguards differ for each system. There is also a need for auditing techniques to check on the effectiveness of the safeguards put into place. The techniques developed will be useful in preventing computer fraud, assuring functional fidelity and maintaining data integrity during input and processing.

16440. Negas, T., Roth, R. S., Parker, H. S., McDaniel, C. L., Olson, C. D., **Chemical aspects of materials containing cerium oxide,** *Proc. 5th European Conf. on Thermophysical Properties of Solids at High Temperatures, Moscow, Russia, May 18-21, 1976*, pp. 1-13 (1976).

Key words: cerium oxide; magnetohydrodynamics; system K_2O-ZrO_2-cerium oxide; thermal microbalance; x-ray diffraction.

The phase relations in the cerium oxide-ZrO_2 system reinvestigated under oxidizing conditions, in air, and up to 1600 °C using thermal microbalance, conventional ceramic heating and quenching, and x-ray diffraction methods. Additionally, reactions of materials of this system with K_2O (the K_2O-ZrO_2-cerium oxide system) are reported. These data are correlated with analyses of electrode materials tested in the U-O2 MHD facility.

16441. Cetas, T. C., **Temperature measurement in microwave diathermy fields: Principles and probes,** *Proc. Int. Conf. on Cancer Therapy by Hyperthermia and Radiation, Washington, DC, Apr. 28-30, 1975*, pp. 193-203 (American College of Radiology, Chevy Chase, MD, 1976).

Key words: measurement temperature; medicine temperature; microwave diathermy fields; temperature measurement.

Thermometry and medicine have been associated closely for a long time. Physicians contributed to the development of various thermometers, and physiological applications were among the first uses of temperature measurement. For example, body temperature or "blood heat" was used as a reference point for some of the early temperature scales. Even today, when the word "thermometer" is used, the clinical thermometer comes to mind most often.

16442. Krauss, M., Neumann, D. B., **The $^5\Sigma_g^+$ states of N_2,** *Mol. Phys.* **32,** No. 1, 101-112 (1976).

Key words: electronic structure; energy curve; N_2; predissociation; radiative recombination; $^5\Sigma_g^+$.

The electronic structure and energy curves of the $1^5\Sigma_g^+$ and $2^5\Sigma_g^+$ states of N_2 have been analyzed using the multiconfiguration self-consistent-field (MC-SCF) method for calculating the wavefunctions and energies. The *ab initio* model curve for the $1^5\Sigma_g^+$ state obtains an r_e of 1.69 Å and a D_e of 825 cm^{-1}. There is also a barrier with a maximum at 2.21 Å with a height of about 800 cm^{-1} which is a novel feature of this calculation. The potential supports two bound vibrational levels and two shape resonances for $j=0$. The calculated curve differs most from the semiempirical curve of Carroll in having a larger r_e by about 0.14 Å and a well depth smaller by 250 cm^{-1}.

The $^5\Sigma_g^+$ curve is known experimentally to predissociate both the $B^3\Pi_g$ and $a^1\Pi_g$ vibration-rotation levels above the dissociation limit. Conversely, two-body radiative association of two $N(^4S)$ atoms is known to occur through the interaction of the $1^5\Sigma_g^+$ and B and a states. The two-body radiative rates are analyzed in terms of the likely spin-orbit interaction between the $1^5\Sigma_g^+$ and B and a states and the ratio of these rates is calculated under the assumption that the predissociation rate exceeds the radiative in both cases. The ratio of the two-body associative rates k^B/k^a is calculated to be roughly 20 which is to be compared to an experimental ratio of 32.

16443. Ditmars, D. A., **Measurement of the average total decay power of two plutonium heat sources in a Bunsen ice calorimeter,** *Int. J. Appl. Radiat. Isot.* **27,** 469-490 (1976).

Key words: Bunsen ice calorimeter; calorimetric standards; calorimetry; heat standards; phase-change calorimeter; plutonium dioxide; plutonium isotopes; radionuclide calorimetry; radionuclide decay power; standards.

A Bunsen ice calorimeter has been specially adapted for high-precision power measurements on radioactive heat sources. The construction of the apparatus, the principles underlying its operation and the interpretation of the heat data obtained in both static and dynamic experiments are thoroughly described. Dynamic electrical calibration experiments yielded a calibration constant for this calorimeter of 270.56 J/g mercury, with an estimated overall inaccuracy of 0.04 percent. This agreed with the present static calibration constant of 270.59 J/g mercury, with an estimated overall inaccuracy of 0.01 percent, well within the combined estimated limits of overall inaccuracy. The average total decay powers of the radioactive heat sources "1.5 WB" and "0.23 WB," supplied by the Mound Laboratory, have been measured. These powers, referred to 27 November 1974, are, respectively, 1.44936 W with an estimated overall inaccuracy of 0.050 percent and 0.22517 W with an estimated overall inaccuracy of 0.144 percent. These limits represent a linear sum of random error calculated at a 99 percent confidence level and estimated maximum systematic error. The decay powers predicted on the basis of heat-flow calorimetry carried out at the Mound Laboratory both before and after the present investigation are 0.004 percent and 0.12 percent above the present results for the sources "1.5 WB" and "0.23 WB," respectively.

16444. Okabe, H., **Fluorescence quenching of sulfur dioxide by source emission gases,** *Anal. Chem.* **48,** No. 11, 1487-1489 (Sept. 1976).

Key words: emission gas; exhaust; fluorescence; nitric oxide; quenching; sulfur dioxide.

The quenching constants of SO_2 fluorescence excited by a 216-nm deuterium source have been obtained for N_2, O_2, air, and CO_2. They are 0.75 ± 0.09, 2.68 ± 0.09, 1.16 ± 0.01, and 0.74 ± 0.07, respectively, all in units 10^{-3} $torr^{-1}$. The fluorescence signal of SO_2 in simulated stack emission is several percent lower than that in pure N_2. The presence of NO does not interfere with the SO_2 measurement by a fluorescence method.

16445. Evans, A. G., Linzer, M., **High frequency cyclic crack propagation in ceramic materials,** *Int. J. Fract.* **12,** No. 2, 217-222 (Apr. 1976).

Key words: ceramic materials; cyclic crack propagation; high frequency; plasticity.

Techniques and instrumentation for studying high frequency cyclic crack propagation in ceramic materials are described. Tests performed on a silicate glass show that the cyclic slow crack growth mechanism up to 600 Hz is identical to the quasi-static mechanism. Conversely, a strong cyclic effect on the crack growth rate is observed in a tungsten carbide-cobalt material.

16446. Powell, F. J., **A fresh look at fundamental design parameters,** *Proc. Energy Crisis Regional Conf., Chicago, IL, Sept. 19-21, 1973,* pp. 24-1–24-8 (Capital Development Board, Springfield, IL, 1973).

Key words: buildings; energy conservation; heat transfer.

Two fundamental equations of heat energy transfer in buildings are examined and related to practical design decisions that are made by architects and engineers. Available modern technology that represents an improvement over the simplified fundamental approach is described. An example of the use of modern technology is given together with suggested ways to save energy in heating and cooling applications. Some of the problems of implementation of energy conservation measures in buildings are discussed.

16447. Branstad, M. A., Branstad, D. K., **Computer security applications utilizing minis,** (Proc. 9th Annual IEEE Computer Society International Conf., COMPCON 74, Fall, Washington, DC, Sept. 10-12, 1974), Paper in *Digest of Papers Micros and Minis, Application and Design,* pp. 91-94 (IEEE Computer Society, Washington, DC, 1976).

Key words: computer security; minicomputers.

Protection of data which is stored and processed in computers is evolving as the highest priority requirement on ADP systems today. Minicomputers are playing a large role in the effort to achieve secure computing environments. They are being used as testbeds to determine the efficacy of various theories on how to design a secure system. Minis are being analyzed for their ability to provide external security control for existing large machines. As computers are being connected in networks, the mini may be instrumental in providing security for the network. These computer security applications utilizing minicomputers are outlined in this paper.

16448. Stolz, A., Bender, P. L., Faller, J. E., Silverberg, E. C., Mulholland, J. D., Shelus, P. J., Williams, J. G., Carter, W. E., Currie, D. G., Kaula, W. M., **Earth rotation measured by lunar laser ranging,** *Science* **193,** 997-999 (Sept. 10, 1976).

Key words: earth rotation; geodesy; geodynamics; geophysics; laser distance measurements; moon.

The estimated median accuracy of 194 single-day determinations of the earth's angular position in space is 0.7 millisecond (0.01 arc second). Comparison with classical astronomical results gives agreement to about the expected 2-millisecond uncertainty of the 5-day averages obtained by the Bureau International de L'Heure. Little evidence for very rapid variations in the earth's rotation is present in the data.

16449. Galloway, K. F., Leedy, K. O., Keery, W. J., **Electron-beam-induced currents in simple device structures,** *IEEE Trans. Parts, Hybrids, Packag.* **PHP-12,** No. 3, 231-236 (Sept. 1976).

Key words: device inspection; electron-beam-induced current; microelectronics; *p-n* junctions; scanning electron microscopy; semiconductor devices.

Electron-beam-induced current (EBIC) in semiconductor devices produced by the electron beam of a scanning electron microscope (SEM) can be used to image subsurface device features and to measure certain material parameters. This paper presents a simple method of calculation for estimating the magnitude of EBIC signals. EBIC signals from silicon *p-n* junction diodes are compared with the results of the calculation. The application of EBIC to more complicated device structures is discussed.

16450. Koonce, C. S., **Superconducting transition widths in applied magnetic fields,** *J. Low Temp. Phys.* **24,** Nos. 5/6, 597-610 (Sept. 1976).

Key words: cadmium; condensation energy; demagnetization coefficient; fluctuations; inhomogeneous superconductor; intermediate state; superconducting-normal transition; superconductor; surface energy type I superconductors.

The width of superconducting-normal transitions for inhomogeneous ellipsoidal superconductors in an applied magnetic field is calculated. A simple model is used for the variation in transition temperature with position and the range of this variation is assumed to be larger than the Landau-Ginzburg coherence length. It is found that the decrease in transition width with increasing applied magnetic fields at low fields occurs because the boundaries between superconducting and normal regions begin to be determinded less by the inhomogeneities and more by the loss of condensation energy between domains, and by sample surface effects. At higher fields, the transition width increases with applied field because of the finite demagnetization coefficient.

16451. Hower, P. L., Blackburn, D. L., Oettinger, F. F., Rubin, S., **Stable hot spots and second breakdown in power transistors,** (Proc. 1976 IEEE Power Electronics Specialists Conf., Cleveland, OH, June 8-10, 1976), *PESC 76 Record, 76-CH, 1084-3 AES,* 234-246 (McGregor and Warner, Washington, DC, Oct. 1976).

Key words: base widening; current crowding; hot spots; power transistors; safe operating area; second breakdown; thermal instability.

The mechanism of hot spot formation in transistors is examined from both experimental and theoretical viewpoints. It is shown that after the device becomes thermally unstable the device may restabilize in a hot spot mode of operation. The I_C, V_{CE} thermal instability locus can accurately be predicted assuming the current density is uniform prior to hot spot formation. A new model is proposed which explains why the device may restabilize in a hot spot mode and why devices exhibit "thermal hysteresis." It is also shown using thermal mapping techniques that emitter current crowding exists in the stable hot spot mode. Finally, the experiments support the idea that second breakdown occurs when the current density within the hot spot reaches a critical value.

16452. McCoubrey, A. O., **The national measurement system and specific industrial needs,** *Proc. Fluid Power Testing Symp., Milwaukee, WI, Aug. 11-14, 1975,* pp. 1.1.1.1-1.1.1.8 (Fluid Power Society, Milwaukee, WI, 1975).

Key words: engineering, instrumentation and techniques; fluids; force; hydraulic equipment; mechanical power; noise; pressure; quality control; safety; testing.

When consideration is given to interrelated needs for measurement methods, units, instruments, reference standards, reference data, and traceability, along with the numerous and diverse public and private agencies involved in measurements activity, it becomes important to think in terms of a *unified measurement system,* and to strive toward the rational design of such a system. An effective system will meet the needs of the users in terms of acceptable and accessible central standards, reliable transfer standards, practical levels of accuracy, cost, and unambiguous language for communication.

The Proceedings of the 1974 Fluid Power Testing Symposium suggest that the need for a unified measurement system for the fluid power industry has been well established. There may now be an opportunity to effectively coordinate the resources of in-

dustry associations, universities, and user government agencies with those of the National Bureau of Standards.

16453. Manning, R. G., Braun, W., Kurylo, M. J., **The effect of infrared laser excitation on reaction dynamics: $O + C_2H_4^\dagger$ and $O + OCS^\dagger$,** *J. Chem. Phys.* **65,** No. 7,2609-2615 (Oct. 1, 1976).

Key words: carbonyl sulfide; chemical kinetics; ethylene; flash photolysis resonance fluorescence; infrared laser; oxygen atoms; vibrationally excited reactant molecules.

A technique involving flash photolytic production and resonance fluorescence detection of O atoms coupled with cw production of vibrationally excited reactant molecules using a CO_2 laser is described. The method relies on the high sensitivity and precision of the flash photolysis resonance fluorescence technique to compare reaction rates measured with the laser off with those measured with the laser on, thereby assessing any effect of reactant vibrational energy on the dynamics of the chemical reaction. The limiting value of the laser enhancement that can be discerned depends ultimately on two factors: (1) the equilibrium concentration of vibrationally excited reactant that can be experimentally realized (i.e., absorption of laser flux vs deactivation losses), and (2) the magnitude of the activation energy for the thermal reaction. This determines the extent of a purely thermal (heating) effect. We observed little or no effect of vibrational energy in C_2H_4 on the rate of reaction with O atoms. Because of a somewhat higher activation energy, it was considerably more difficult to measure an effect in the O + OCS reaction. Within the limits of detectability, all observations in this system could be attributed to heating effects. A factor of 1.5 increase in the rate constant for $O + C_2H_4^\dagger$ over that for $O + C_2H_4$ and a factor of 3 for $O \pm OCS^\dagger$ over O + OCS would have been detectable in these experiments. The results seem to indicate that there is little or no coupling of vibrational energy to the reaction coordinate leading to activated complexes in these two reaction systems.

16454. Gadzuk, J. W., **Electron spectroscopy of surfaces via field and photoemission,** Paper in *Electronic Structure and Reactivity of Metal Surfaces*, E. G. Derouane and A. A. Lucas, Eds., pp. 341-387 (Plenum Publishing Corp., New York, NY, 1976).

Key words: chemisorption; ESCA; field emission; photoemission; surfaces; x-ray photoemission.

A review and survey of some of the basic physics involved in field and photoemission spectroscopy of surfaces is presented. Special emphasis is placed on the role of spatial coherence in determining the noninteracting electron photoemission characteristics of surfaces. Many-body effects, in particular the static response leading to relaxation energies and the dynamic response resulting in satellite structures are treated and the connection between them is demonstrated.

16455. Klein, M., Haar, L., **Equilibrium compositions and compressibility factors for air in the temperature range 1500 to 13000 kelvin and for densities from 10^{-6} to 10^3 times standard density,** *AEDC-TR-76-85*, 77 pages (Available from the National Technical Information Service, Springfield, VA 22161, June 1976).

Key words: air; gases; high density; mixtures; thermodynamic properties.

A formalism for computing thermodynamic properties and equilibrium compositions of reacting gas mixtures at high densities is developed. This formalism makes use of the Haar-Shenker version of the augmented hard sphere equation of state. The formalism is used for computing compressibility factors and equilibrium compositions of air in the temperature range 2,000 K-13,000 K for densities from that appropriate to air at standard conditions (0 °C, 1 atmosphere) to densities 1000 times as great. These tables are consistent with the earlier NBS tables which covered the range up to 100 times that density. Some interesting features of the dependence of composition on density are discussed.

16456. Kaldor, A., Woodward, B. W., **Infrared laser monitoring techniques for NO and NO_2,** *AIChE Symp. Ser.* **71,** No. 148, 183-189 (1974).

Key words: apparatus and methods; infrared lasers; magnetic resonance; molecular spectroscopy; NO, NO_2, pollutant detection.

The concentration of NO and NO_2 can be monitored by several different infrared laser devices and techniques. These include laser sources such as a CO laser, tunable diode lasers, tunable spin-flip Raman laser, etc. and detection techniques such as Zeeman magnetic resonance, intracavity absorption, and optoacoustic devices. Sensitivities to the ppb range have been demonstrated. These different methods are discussed and evaluated.

16457. Cook, L. P., Plante, E. R., Negas, T., Roth, R. S., Olson, C. D., **Crystallization and vaporization studies on synthetic coal slag compositions,** *Proc. 15th Symp. on Engineering Aspects of Magnetohydrodynamics, Philadelphia, PA, May 24-25, 1976*, pp. II.4.1-II.4.6 (1976).

Key words: crystallization; magnetohydrodynamics; potassium activity; synthetic coal slags; system K_2O-CaO-Al_2O_3-SiO_2; vaporization.

Insight as to the chemical behavior of coal slags accumulating on the walls of MHD systems can be gained by examining the results of high temperature experiments on K_2O-CaO-Al_2O_3-SiO_2 mixtures. An increase in CaO content may increase a_{K_2O} appreciably for certain compositions. Potassium aluminate–silica solid solutions, some of which are relatively water soluble, occur over a significant range of silica-poor and Ca-rich compositions at 1400 °C.

Two synthetic slags, with compositions falling close to an observed distribution of coal ash analyses, have been studied with the mass spectrometer using the Knudsen effusion technique. One slag having initially 15 wt% CaO yielded a higher K pressure at 10 wt% K_2O than a K_2O-SiO_2 solution containing 30 wt% K_2O. A second slag with relatively high SiO_2 and Al_2O_3 and 13 wt% K_2O gave a K pressure above that of a K_2O-SiO_2 solution with 20 wt% K_2O.

16458. McDonald, D. G., **Josephson junctions as radiation detectors from millihertz to terahertz,** *IEEE J. Quantum Electron.* **QE-10,** No. 9, 776-777 (Sept. 1974).

Key words: cryogenics; infrared; Josephson junctions; lasers; radiation detectors; superconductors.

The early experiments using Josephson junctions as mixers or detectors were at frequencies below a few hundred GHz. Recently we have shown that Josephson junctions can be used as mixers at much higher frequencies, particularly at CO_2 laser frequencies.

16459. Olver, F. W. J., **Uniform asymptotic expansions and singular perturbations,** *SIAM-AMS Proc.* **10,** 105-117 (American Mathematical Society, Providence, RI, 1976).

Key words: boundary-value problem; eigenvalues; parabolic cylinder functions; resonance; rotating disks; singular perturbations; turning-point; viscous flow; Weber's equation.

A brief account is given of an investigation into the asymptotic nature of the solution of the boundary-value problem

$$\epsilon y'' + 2xA(\epsilon,x)y' - A(\epsilon,x)B(\epsilon,x)y = 0,\ y(a) = l,\ y(b) = m,$$

as $\epsilon \to 0$, where $A(\epsilon,x)$ and $B(\epsilon,x)$ are continuous real functions of ϵ and x, $a < 0$, $b > 0$, and $A(\epsilon,x)$ is nonzero in $[a,b]$. Particular attention is paid to the problem of resonance, which arises when the limiting form of the solution exhibits an unusual lack of decay (in the case $A(\epsilon,x) < 0$), or an unusual rate of growth (in the case $A(\epsilon,x) > 0$). By application of a recent theory of differential equations with coalescing turning points sufficient conditions for resonance are established, both with and without the assumption that $A(\epsilon,x)$ and $B(\epsilon,x)$ are analytic functions of ϵ and x.

Fuller details will be published elsewhere.

16460. Yates, J. T., Jr., Klein, R., Madey, T. E., **Adsorption of molecular nitrogen by the W(110) plane,** *Surface Sci.* **58,** 469-478 (1976).

Key words: adsorption; nitrogen; physical adsorption; tungsten; work function.

Characteristics of the adsorption of nitrogen on the (110) plane of tungsten were determined by thermal desorption and work function measurements. The low temperatue γ-N_2 state desorbs with first order kinetics and an activation energy of 6 kcal mole^{-1}. The absence of isotope mixing between $^{14}N_2$ and $^{15}N_2$ demonstrates γ-N_2 is adsorbed molecularly. Monolayer coverage shows a decrease of 0.19 eV in work function. A Topping model plot indicates the layer is immobile at 123 K.

16461. Wyatt, W. T., Jr., Lozier, D. W., Orser, D. J., **A portable extended precision arithmetic package and library with Fortran precompiler,** *ACM Trans. Math. Software* **2,** No. 3, 209-231 (Sept. 1976).

Key words: elementary function evaluation; extended precision arithmetic; floating point arithmetic; Fortran extended data types; Fortran precompiler.

A set of ANS Fortran subroutines, developed by W. T. Wyatt, which incorporates computer-independent algorithms for performing arithmetic on arbitrary length, extended precision, floating point, real, or complex numbers in any user-designated computation base from 2 to 16 is described. Also included is a library of the Fortran intrinsic and external (mathematical) functions, as well as routines for type conversion, base conversion, input/output, and other operations. Analysis and testing, by D. W. Lozier, of the arithmetic and library software to locate and eliminate errors and to determine approximate accuracy limits is described. Finally, a precompiler, written in Fortran by D. J. Orser, which translates a Fortran program containing two extended precision data types (SUPER PRECISION and SUPER COMPLEX) into an ordinary Fortran program that uses subroutine calls to the software to carry out the extended precision operations is described. The software is intended to furnish working scientists who are not specialists in computer science a ready means of computing in extended precision.

16462. Weber, L. A., **Dielectric constant data and the derived Clausius-Mossotti function for compressed gaseous and liquid ethane,** *J. Chem. Phys.* **65,** No. 1, 446-449 (July 1, 1976).

Key words: Clausius-Mossotti function; dielectric constant; equation of state (PVT); ethane.

Measurements are presented for the dielectric constant of ethane in the saturated liquid and compressed fluid states at temperatures between 95 and 323 K. Pressures ranged up to 390 bar. The data, which have an estimated uncertainty of 0.01 percent, are combined with accurate density data from several sources to produce the Clausius-Mossotti function over a wide range of temperature and density. An analytical expression of the Clausius-Mossotti function is given, and the consistency of the available density data is discussed.

16463. Andrews, J. R., **Impulse generator spectrum amplitude measurement techniques,** *CPEM Digest,* pp. 23-24 (1976).

Key words: calibration; Fourier transform; impulse generator; pulse measurement; spectrum; spectrum amplitude.

This paper discusses the various techniques that have been used to calibrate impulse generators and to measure spectrum amplitude. The techniques included are (1) standard transmission line, (2) harmonic measurement, (3) energy measurement, (4) sum and difference correlation radiometer, (5) Dicke type radiometer, (6) video pulse, MIL. Std. 462, (7) spectrum analyzer, (8) standard pulse comparison, and (9) time domain measurement with Fourier transformation computation. Advantages and disadvantages of each technique are discussed. A summary of experiments comparing the various techniques is included. The NBS measurement service for calibrating impulse generators is described.

16464. Baird, R. C., **Methods of calibrating microwave hazard meters,** *Proc. Int. Symp. on Biologic Effects and Health Hazards of Microwave Radiation, Warsaw, Poland, Oct. 15-18, 1973,* pp. 228-236 (Polish Medical Publ., Warsaw, Poland, 1974).

Key words: microwave hazard meters; microwave radiation.

Accurate and reliable measurements of microwave radiation are required for hazard surveys, leakage detection, testing of products for compliance with regulations, and for determining exposure levels in experiments designed to investigate the biologic effects of microwave radiation. Accurate calibration of the instruments used for these measurements is essential for safety reasons and to provide a basis for comparison of the experimental results of various laboratories.

16465. Birmingham, B. W., Smith, C. N., **A survey of large scale applications of superconductivity in the U.S.,** *Cryogenics* **16,** No. 2, 59-71 (Feb. 1976).

Key words: cryogenics; CTR; electric power; energy storage; generators; instrumentation; MHD; superconductivity.

This survey provides a general overview of the kind and amount of research being done in the U.S. on large-scale applications of superconductivity. It covers about $30 million worth of research and development on systems and devices, and excludes programs on superconducting phenomena or basic studies of properties of materials unless they are part of an applications program. It covers the categories of electric power systems (generation, transmission, and storage); high energy physics; and instrumental-industrial-medical applications. Data were gathered through personal contact and letters to the researchers involved, and include funding and manpower levels where possible.

16466. Carroll, J. J., Melmed, A. J., **Field ion microscopy of zirconium,** *Surface Sci.* **58,** No. 2, 601-604 (Aug. 1976).

Key words: field-ion microscopy; zirconium.

Zirconium was successfully imaged in the field ion microscope using neon ions and mixtures of helium and neon ions at specimen temperatures of about 30K. Micrographs obtained after zirconium was exposed to hydrogen imaging conditions showed features that may indicate the early stage development of cracks, mostly along the $\{11\bar{2}0\} - \{11\bar{2}2\}$ zone. Crack defects were confined to at least the topmost 2-5 layers.

16467. Carroll, J. J., Melmed, A. J., **Optical constants of (1120) ruthenium in the visible region,** *J. Opt. Soc. Am.* **66,** No. 10, 1050-1051 (Oct. 1976).

Key words: ellipsometry; optical constants; ruthenium.

Optical constants are reported for $(11\bar{2}0)$ ruthenium measured ellipsometrically in the visible spectrum under ultrahigh vacuum conditions. The results are compared to literature values.

16468. Clough, R. B., **Rational basis and new methods for proportional limit, machine stiffness, critical stress intensity, and crack velocity measurements,** (Proc. 78th Annual Meeting American Society for Testing and Materials, Montreal, Canada, June 22-27, 1975), *Am. Soc. Testing Mater. Spec. Tech. Publ. 608, Recent Developments in Mechanical Testing,* pp. 20-44 (1976).

Key words: crack propagation; determination of stress; measurement; mechanical tests; plastic deformation; proportional limit.

This paper is a summary of some new measurement techniques that have been developed recently at the National Bureau of Standards for measurement of proportional limit of elasticity, machine stiffness, critical stress intensity, and crack velocity. These seemingly unrelated measurements all result from the rational basis of a single type of equation relating specimen and machine kinetics. In a regime of linear elasticity, the concept of a limit beyond which the specimen elastic gage length displacement is no longer proportional to load is referred to as proportional limit if the gage length begins to exhibit plastic deformation, and is referred to in a precracked specimen as critical stress intensity if the crack begins to extend in length. Multiaxial plastic yielding is also discussed. Machine stiffness and crack velocity are other measurements which can be obtained through the specimen-machine equation. The relationship of the new stiffness measurement to the International Standards Organization (ISO) proposed method and advantages of the new method are discussed. Methods of measuring stiffness in constant load rate and constant strain rate tests are outlined. A method of measuring the proportional limit or critical stress intensity which does not use a displacement gage of any type is also given; this should prove useful in hostile environments. Other related topics discussed include loading transients and rate sensitivity.

16469. Crawford, M. L., **Experimental evaluation of the radiation characteristics of dipole sources enclosed in a TEM transmission cell,** *CPEM Digest,* pp. 57-59 (1976).

Key words: measurements; radiated emission; radiation resistance; TEM cells.

This paper describes measurements to verify theoretical formulation of the changes in the radiation resistance of electronic equipment enclosed inside a special type shielded enclosure, a rectangular TEM cell. The measurements were made, assuming the device under test (DUT) could be modeled by dipole sources, using a monopole antenna mounted at various locations inside a typical cell. The predicted radiated power from the monopole antenna mounted inside the cell was within ± 2 dB of the energy coupled to the cell's output ports. These results are contained in the paper and give credibility to the ability to relate such measurements to free space radiation conditions.

16470. Crawford, M. L., **Calibration of broadbeam antennas using planar near-field measurements,** *CPEM Digest,* pp. 53-56 (1976).

Key words: broadbeam antennas; planar near field measurements.

This paper describes techniques for improving and extending planar near field (PNF) measurements for use in calibrating broadbeam antennas (gain ≥ 3 dB). This application requires minimizing errors associated with the PFN formulations: specifically, the assumptions that 1) all significant near fields associated with the test antenna fall within the measurement scan area and 2) that multiple reflections between test antenna, probe, and their surroundings are negligible. The techniques discussed include: 1) optimizing the scan parameters (e.g., size of scan area, data point spacing, and separation distance between the test antenna and measure plane); 2) simulating measurements taken over an extended, enlarged, scan area; 3) minimizing multipath error; and 4) use of data deletion and extrapolation to obtain the test antenna's on-axis gain calibration. The paper also contains results of measurements made using a typical broadbeam antenna. These results include comparisons made between a far field pattern obtained using PNF scanning and using a conventional far field range.

16471. Day, G. W., Hamilton, C. A., Gruzensky, P. M., Phelan, R. J., Jr., **Performance and characteristics of polyvinylidene fluoride pyroelectric detectors,** (Proc. IEEE Symp. on Application of Ferroelectrics, Albuquerque, NM, June 9-11, 1975), *Ferroelectrics* **11,** 99-102 (1976).

Key words: infrared detectors; polymers; pyroelectrics; radiometry.

Pyroelectric detectors based on the polymer film polyvinylidene fluoride should be recognized as attractive choices for applications where a high detectivity coupled with a broad spectral response and a large area are required. Devices with a 1 cm^2 area typically have a detectivity of $10^9 f^{1/2}$ cm $Hz^{1/2}/W$ where f is the frequency in Hz. Fabrication may be directly from commercially available film or with some additional processing. Several instruments incorporating these detectors have been developed to solve certain radiometric measurement problems.

16472. Day, G. W., Hamilton, C. A., Pyatt, K. W., **Spectral reference detector for the visible to 12-μm region; convenient, spectrally flat,** *Appl. Opt.* **15,** No. 7, 1865-1868 (July 1976).

Key words: detector; infrared; pyroelectric; spectral response.

A convenient spectral reference detector for the visible to 12-μm region has been developed. The device consists of a large area PVF_2 pyroelectric detector enclosed in a hemispherical light trap. Based on theoretical and experimental evaluations, the detector response is independent of wavelength to ± 1 percent over this spectral range.

16473. Domen, S. R., Lamperti, P. J., **Comparisons of calorimetric and ionometric measurements in graphite irradiated with electrons from 15 to 50 MeV,** *Med. Phys.* **3,** No. 5, 294-301 (Sept.-Oct. 1976).

Key words: absorbed dose; calorimeter; electrons; heat defect in graphite.

Extensive experimental comparisons of calorimetric and ionometric measurements have been made that cover a broader range of electron energies and depths in graphite than previously reported. Electron beams of 15, 20, 25, 30, 40, and 50 MeV were used. Calorimetric absorbed-dose measurements and ionometric specific-charge measurements in air were compared in graphite at depths from 1 to 51 g/cm^2. The medium was irradiated with uncollimated electron beams produced by scattering after passing through a 0.1-g/cm^2 aluminum vacuum window, various thicknesses of lead foils, and air. The variation in the quotient of the two measurements was studied as a function of lead-foil thickness, depth in the medium, beam energy, foil-to-detector

distance, and off-axis distance. These studies permitted the measurements to be corrected and compared with theoretical calculations that assume a broad medium irradiated with broad, parallel, monoenergetic electron beams. The overall experimental uncertainty is estimated to be 1 percent. The results are generally in good agreement with theoretical and experimental results of other investigators. The calorimeter received close to 1 Mrad during preliminary measurements and from 1 to 2 Mrad during the measurements reported. The results showed no detectable heat defect in graphite after prolonged periods of exposing the calorimeter to air at atmospheric pressure.

16474. Ekin, J. W., **Effect of stress on the critical current of Nb_3Sn multifilamentary composite wire,** *Appl. Phys. Lett.* **29,** No. 3, 216-219 (Aug. 1, 1976).

Key words: critical currents; magnets; magnet wire; Nb_3Sn; Nb_3Sn magnets; Nb_3Sn multifilamentary wires; strain; stress; superconducting magnets.

A critical-current study of flexible Nb_3Sn multifilamentary composite wires has been conducted at 4 K in magnetic fields to 90 kOe (7.2×10^6 A/m) while the wire is subjected to high mechanical stresses. The results show that at stresses above 1-2 $\times 10^8$ Pa (strains of 0.1-0.2%) the critical current is significantly degraded, with the magnitude of the reduction dependent on reinforcement techniques used in the wire's construction. The effect increases with magnetic field and results in the introduction of significant resistance at current levels well below the zero-stress critical current. Design considerations for the use of Nb_3Sn wires in the high-stress environments of large-scale superconducting magnets are discussed.

16475. Engen, G. F., **Measurement of complex microwave circuit parameters using only power detectors,** *CPEM Digest,* p. 171 (1976).

Key words: automatic network analyzer; microwave; microwave measurement; six-port.

Although straightforward in principle, the extension of existing designs for automatic network analyzers to the higher microwave frequencies is difficult in the current state-of-the-art. What appears to be needed is a basically different approach to the microwave detection problem. This is provided by the so-called "six-port" techniques, which eliminate the need for frequency conversion, local oscillators, phase detectors, etc. Recent theoretical studies have provided new insights into the basic concept and lead to "five-port" configurations which require three instead of four amplitude detectors. Of particular interest is the useful measurement dynamic range of 50-60 dB corresponding to an intrinsic dynamic range required in the amplitude detectors of a nominal 20 dB or less.

16476. Estin, A. J., **Scattering parameters of SMA coaxial connector pairs,** *CPEM Digest,* pp. 110-111 (1976).

Key words: coaxial connectors; connectors; RF connectors; SMA connectors.

A technique is described for making insertion loss and reflection measurements on SMA connectors mounted on solid-dielectric coaxial line. Results are given for measurements of $|S_{11}|$ and $|S_{21}|$ of eight test pairs over the frequency range of 4 to 12 GHz.

16477. Gans, W. L., **Present capabilities of the NBS automatic pulse measurement system,** *CPEM Digest,* pp. 25-26 (1976).

Key words: automated measurement; pulse; rise time; sampling oscilloscope; spectrum amplitude; time domain; transient.

In 1972, NBS began development of an Automatic Pulse Measurement System (APMS) consisting essentially of a minicomputer-controlled wideband sampling oscilloscope. The objective of the work was to produce a fast, general purpose transient waveform acquisition and processing instrument covering the frequency range dc-18 GHz. The purpose of this paper is to report the highlights of work done on the APMS from early 1975 to present.

The measurement applications of the APMS now consist of both publicly offered calibration services and inhouse experimental measurements. In the first category, calibration services are available for the following physical parameters: a. Impulse generator spectrum amplitude; b. Wideband coaxial attenuation/gain; c. Low pass filter risetime; d. Pulse generator risetime.

Still in the experimental stage are measurements involving reflection coefficient and impedance, group delay, pulse distortion, and wideband antenna characteristics. In addition, the APMS is quite often used for theoretical modeling and model/experiment comparison and verification.

16478. Ginsberg, D. M., Harris, R. E., Dynes, R. C., **Strong-coupling correction to the low-frequency electrical conductivity of superconductors and Josephson junctions,** *Phys. Rev. B* **14,** No. 3, 990-992 (Aug. 1, 1976).

Key words: electron tunneling; electronic devices; far infrared; Josephson effect; strong electron-phonon coupling; superconductivity.

Values of the strong-coupling correction to the low-frequency local-limit conductivity of a number of superconductors are given. These values also describe the strong-coupling correction to the critical current of a Josephson tunnel junction. The correction is given for indium, amorphous gallium, β-phase gallium, amorphous bismuth, $Pb_{0.8}Bi_{0.2}$, $Pb_{0.7}Bi_{0.3}$, amorphous $Pb_{0.45}Bi_{0.55}$, $Tl_{0.9}Bi_{0.1}$, $Pb_{0.8}Tl_{0.2}$, and previously published values are listed for tin, lead, mercury thallium, and indium-thallium alloys. It is shown that there is a simple empirical relation between these values and the effective electron-electron coupling parameter ($\lambda - \mu^*$).

16479. Unassigned.

16480. Greer, S. C., **Coexistence curves at liquid-liquid critical points: Ising exponents and extended scaling,** *Phys. Rev. A* **14,** No. 5, 1770-1780 (Nov. 1976).

Key words: binary mixture; coexistence curve; critical phenomena; density; isobutyric acid; magnetic densimeter; phase equilibria, carbon disulfide, nitromethane; water.

New measurements have been made of coexisting mass densities of isobutyric acid and water with a precision of 20 ppm and within 3.5 °C of the critical temperature. The measurements were made using a single sample of composition very close to critical. It is found that the coexistence curve is more symmetric in terms of the difference in volume fraction ($\Delta\phi$) of coexisting phases than in terms of the difference in mass density. The difference $\Delta\phi$ is well fitted for $\epsilon = (T_c - T)/T_c < 0.006$ by the expression $\Delta\phi = B\epsilon^\beta$, where $B = 1.071 \pm 0.023$ and $\beta = 0.328 \pm 0.004$. (Uncertainties are given as 3 times the standard deviation.) A new analysis has been made of the recent data of Gopal *et al.* on the difference in volume fraction of coexisting densities of carbon disulfide and nitromethane. For this system, $\Delta\phi$ can be fitted for $\epsilon < 0.2$ by an extended scaling expression suggested by Wegner's work, $\Delta\phi = B\epsilon^\beta + B_1\epsilon^{\beta+\Delta} + B_2\epsilon^{\beta+2\Delta}$. The exponent Δ_2 is fixed at 0.5; the fit gives $\beta = 0.316 \pm 0.008$, $B = 1.63 \pm 0.09$, $B_1 = 0.77 \pm 0.31$, and $B_2 = -2.43 \pm 0.40$. This work suggests that liquid-liquid critical phenomena are consistent with the functional forms obtained from renormalization-group calculations

and with asymptotic exponents which are like those presently calculated for the Ising model. The range of asymptotic behavior seems to be larger for a liquid-liquid critical point than for a liquid-gas critical point.

16481. Hammond, G. A., Brown, W. B., Yolken, H. T., **National program of measurements and standards for safeguarding nuclear materials,** (Proc. 17th Annual Meeting Institute of Nuclear Materials Management, Inc., Seattle, WA, June 22-24, 1976), Paper in *Nuclear Materials Management* **V,** No. III, 351-360 (1976).

Key words: fuel; materials accountability; measurements; nuclear; safeguards; standards.

A national measurement and standards program is described which is coordinated essentially by the Nuclear Regulatory Commission, the National Bureau of Standards and the Energy Research and Development Administration. Efforts and progress are outlined as related to assuring that timely, accurate measurements at reasonable cost are available to the nuclear community. The results of this combined effort show that programs are underway to keep abreast of the present measurement needs for nuclear materials safeguards, and that projected work is consistent with a growing U.S. nuclear industry.

16482. Hanley, H. J. M., **Comment on "Citation analysis: A new tool for science administrators",** *Science News and Comment* **188,** No. 4193, 1064 (June 1975).

Key words: citation index.

Comment on "News and Comment" item, entitled "Citation Analysis: A New Tool for Science Administrators," appearing in *Science*, **188,** 4187, p. 429, May 2, 1975.

16483. Hanley, H. J. M., Cohen, E. G. D., **Analysis of the transport coefficients for simple dense fluids: The diffusion and bulk viscosity coefficients,** *Physica* **83A,** 215-232 (1976).

Key words: argon; bulk viscosity; density expansion; methane; modified Enskog theory; molecular correlations; nitrogen; sound absorption.

The analysis of transport coefficients based on the modified Enskog theory (MET), discussed in a previous publication, has been extended to include the self-diffusion coefficient *(D)* and the bulk viscosity coefficient (η_v). Specifically, calculated values according to the MET are compared with experiment over the range for which data are available. Fluids considered are argon, nitrogen and methane. Agreement between theory and experiment for densities less than about twice the critical density (ρ_c) is generally within about 10 percent. However, much of the data was taken at densities well in excess of $2\rho_c$ in which case agreement is still not unsatisfactory. Deviations exceeding 10 percent between theoretical and experimental self-diffusion coefficients were observed for densities in the approximate range $0.9 \lesssim \rho/\rho_c \lesssim 2.0$. It is possible that these deviations are due to long range correlated molecular motions which are not present in the MET. The sound absorption is also briefly considered. Finally, the behavior of η_v and D at low densities is discussed.

16484. Hanley, H. J. M., Sengers, J. V., Ely, J. F., **On estimating thermal conductivity coefficients in the critical region of gases,** *Proc. 14th Int. Conf. Thermal Conductivity, Storrs, CT, June 2-4, 1975,* Paper R-960, pp. 383-407 (Plenum Publ. Corp., New York, NY, 1976).

Key words: correlation length; critical point; gas-liquid; nonspherical molecules; Ornstein-Zernike theory; thermal conductivity.

The thermal conductivity of a fluid exhibits a pronounced anomalous increase in a large range of densities and temperatures around the gas-liquid critical point. In this paper we discuss an attempt to estimate the thermal conductivity in the critical region of fluids from a knowledge of the equilibrium properties and the regular behavior of the transport properties outside the critical region.

16485. Harris, R. E., **Intrinsic response time of a Josephson tunnel junction,** *Phys. Rev. B* **13,** No. 9, 3818-3821 (May 1, 1976).

Key words: electronics devices; high speed devices; Josephson effect; superconducting devices; superconductivity; tunneling.

The microscopic theory of the Josephson effect is reformulated in the time domain. The four terms in the usual theory are seen to be necessary consequences of intrinsic junction delays. The tunneling current flowing in response to a voltage pulse is shown to rise in a time $\hbar/2\Delta$ and undergo damped energy-gap oscillations, before approaching the expected supercurrent. The theory provides a technique for calculating junction behavior when connected to an arbitrary circuit.

16486. Harris, R. E., Dynes, R. C., Ginsberg, D. M., **Strong-coupling correction to the jump in the quasiparticle current of a superconducting tunnel junction,** *Phys. Rev. B* **14,** No. 3, 993-995 (Aug. 1, 1976).

Key words: electronic devices; electron tunneling; Josephson effect; strong electron-phonon coupling; superconductivity.

Calculated values of the strong-coupling correction to the jump in the quasiparticle current of superconductor-insulator-superconductor tunnel junctions are given for a number of elements, amorphous materials, and alloys. It is shown that there is a simple empirical relation between the size of jump in the quasiparticle current and the effective electron-electron coupling parameter $(\lambda - \mu^*)$.

16487. Hellwig, H., Allan, D. W., Jarvis, S., Jr., Glaze, D. J., **The realization of the second,** (Proc. Fifth Int. Conf. on Atomic Masses and Fundamental Constants (AMCO-5), Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., pp. 330-336 (Plenum Publ. Corp., New York, NY, 1975).

Key words: atomic beams; atomic clock; atomic time; cesium beam tube; definition of the second; frequency accuracy; international atomic time; primary frequency standard.

We report realizations of the unit of time with an accuracy approaching 1×10^{-13} using our two primary cesium beam standards. Quantitative values are given for the requirements on operating parameters of such devices in order to assure high frequency stability. Principal design limitations and fundamental approaches to overcome them are discussed. The concept of a servo which maintains accuracy is advanced which would allow primary standards to operate continuously as clocks without loss in their evaluated accuracy.

16488. Hellwig, H., Allan, D. W., Walls, F. L., **Time and frequency,** (Proc. Fifth Int. Conf. on Atomic Masses and Fundamental Constants (AMCO-5), Paris, France, June 2-6, 1975), Paper in *Atomic Masses and Fundamental Constants*, J. H. Sanders and A. H. Wapstra, Eds., pp. 305-311 (Plenum Publ. Corp., New York, NY, 1975).

Key words: clocks; frequency accuracy; frequency stability; frequency standards; infrared frequency multiplication; noise; time scale; time standards.

A comparison of the accuracy and stability performance of precise frequency standards is given. It is shown that measure-

ment systems exist which comfortably allow the full characterization of these standards. The importance of spectrally pure oscillators for frequency synthesis into the infrared region is discussed quantitatively. The problem of absolute accuracy in timekeeping is reviewed.

16489. Hellwig, H., Wainwright, A. E., **A portable rubidium clock for precision time transport,** *Proc. 7th Annual Precise Time and Time Interval (PTTI) Planning Meeting, Washington, DC, Dec. 2-4, 1975,* pp. 143-159 (Goddard Space Flight Center, Greenbelt, MD, 1976).

Key words: atomic clocks; frequency stability; portable clocks; rubidium frequency standard; time comparison.

Based on a commercially available rubidium standard the National Bureau of Standards (NBS) developed a portable rubidium clock. Technical modifications which reduce the sensitivity against temperature, magnetic environment, and barometric changes allow stabilities in the 10^{-12} range under typical clock transport conditions. Under laboratory conditions the clock shows a best stability of 3 parts in 10^{14}. Clock packages based on sealed lead-acid batteries featuring a total weight of 21 kg and 18 hours battery operation were tested; an improved clock package was realized using silver-zinc batteries with 11 kg weight and 28 hours battery operation. Report of several clock trips to the U.S. Naval Observatory and of one clock trip each to the Bureau International de l'Heure in Paris and to the Hewlett-Packard Company in Santa Clara, California are reported. Time transport precisions of .02 μs have been obtained. Special aspects of the clock modifications and the operating characteristics are discussed, as well as an optimal use of the data of a clock round-trip.

16490. Hoer, C. A., Roe, K. C., Allred, C. M., **Measuring and minimizing diode detector nonlinearity,** *CPEM Digest,* pp. 108-109 (1976).

Key words: detectors; diodes; linearity; square-law.

This paper describes a technique for measuring the linearity of amplitude detectors in general, and for measuring the deviation from square-law, E, of point-contact diode detectors in particular. A general mathematical model is given for determining the rf input power as a function of the detector output voltage. For point-contact diodes it is shown how to choose the video load resistance to minimize E, as well as how to calculate and correct for E.

16491. Holste, J. C., Lawless, W. N., Samara, G. A., **Dielectric properties of KH_2PO_4, $BaTiO_3$, $PbZr_{0.65}Ti_{0.35}O_3$ and TlCl between 0.015 and 10 K,** (Proc. IEEE Symp. on Application of Ferroelectrics, Albuquerque, NM, June 9-11, 1975), *Ferroelectrics* **11,** 337-340 (1976).

Key words: barium titanate; dielectric properties; ferroelectrics; KDP; PZT 65/35; thallium chloride; very low temperatures.

The small-signal ac permittivities (ϵ) of single crystal samples of KDP, $BaTiO_3$, and TlCl, and of a ceramic sample of PZT 65/35 have been measured as a function of temperature between 0.015 and 10 K. For KDP and PZT 65/35, ϵ increases essentially linearly with temperature in this range, with $d \ln \epsilon/dT = 0.95 \pm 0.15 \times 10^{-3}$ K^{-1} and $1.81 \pm 0.02 \times 10^{-3}$ K^{-1}, respectively. For $BaTiO_3$ linear behavior is observed only between 1.5 and 4.5 K, with $d \ln \epsilon/dT = 9.4 \times 10^{-4}$ K^{-1}. PZT 65/35 exhibits positive deviation from this apparent linear behavior between 0.1 and 1.5 K, while $BaTiO_3$ shows a negative deviation in this range. Both PZT 65/35 and $BaTiO_3$ have a minimum in ϵ below 0.1 K and an associated change in the dielectric loss factor that depends on the frequency and amplitude of the ac signal. No temperature dependence of ϵ was observed below 3 K for TlCl. Potential applications of these materials at low temperatures are discussed.

16492. Howe, D. A., **Precise frequency dissemination using the 19-kHz pilot tone on stereo FM radio stations,** *IEEE Trans. Broadcast.* **BC-20,** No. 1, 17-20 (Mar. 1974).

Key words: frequency modulation; modulation index; multipath; path delay; phase vs. time; σ vs. τ, 19 kHz pilot.

A continuous 19-kHz pilot tone is included as part of the modulation format of stereo FM broadcast radio stations. An experiment was performed which measures the stability of the received pilot in urban rural environments. A mathematical analysis is presented of the phase stability of the received pilot as a function of multipath. It shows that phase changes will exist dependent upon a reflected radio signal's phase lag, relative amplitude, and the modulation index. Data are presented which indicate: 1) phase versus time of the pilot at the National Bureau of Standards (NBS) laboratory using a directional yagi and a vertical whip; 2) Allan variance measurements of σ versus τ using a directional yagi; and 3) the day-to-day phase delay of the pilot at five urban locations and three rural locations using a vertical whip. With 5 min of averaging time, the delay of the pilot at five urban sites was reproducible to within 2 μs each day over a five-day period. Delay was reproducible to within 0.8 μs at three urban sites.

16493. Howell, B. F., Margolis, S., Schaffer, R., **Detection of inhibitors in reduced nicotinamide adenine dinucleotide by kinetic methods,** *Clin. Chem.* **22,** No. 10, 1648-1654 (1976).

Key words: Michaelis constants for NADH and LDH-5; LDH-1.

Methods are described for detection of lactate dehydrogenase (LDH) inhibitors in preparations of reduced nicotinamide adenine dinucleotide. They are (a) comparison of values by kinetic methods with those measured for highly purified NADH and (b) examination of Lineweaver-Burk plots. Chromatographic inhomogeneities are correlated with deviant values for the kinetic constants of NADH preparations. Lineweaver-Burk plots that curve upward at the high concentrations or have a larger or smaller than normal slope may indicate the presence of inhibitor. As determined in bicarbonate buffer (0.11 mol/liter, pH 7.9) by use of 0.600 mmol/liter pyruvate and NADH freshly separated from impurities by chromatography on diethylaminoethyl-cellulose, the K_m (apparent) of NADH at 25 °C has the value 8.11 ± 0.71 μmol/liter (SD, n = 28) with LDH-1 (pig heart, 2.48 ± 0.05 U per milliliter of reaction mixture, or 41.3 ± 0.8 nmol/liter per second). Under similar conditions, the K_m (apparent) of NADH has the value of 8.57 ± 1.58 mol/liter (SD, n = 21) with LDH-5 (pig muscle, 1.77 ± 0.03 U/ml of reaction mixture), or 29.4 ± 0.6 nmol/liter per second). At infinite substrate concentrations with the same pH, buffer, and temperature, the K_m (apparent) for NADH was 26.0 ± 0.63 μmol/liter with LDH-1 and 23.2 ± 4.6 μmol/liter with LDH-5.

16494. Hust, J. G., **Standard reference materials for thermal conductivity and electrical resistivity,** *Proc. 14th Int. Conf. Thermal Conductivity, Storrs, CT, June 2-4, 1975, Paper R-958,* pp. 221-231 (Plenum Publ. Corp., New York, NY, 1976).

Key words: austenitic stainless steel; electrical resistivity; high temperature; low temperature; standard reference materials; thermal conductivity.

A brief historical review is presented of thermal conductivity reference material research. Recent reference material research by the National Bureau of Standards is described. Critically evaluated thermal conductivity and electrical resistivity data are summarized for the following three Standard Reference Materi-

als now available from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C.: electrolytic iron (4 to 1000 K), austenitic stainless steel (4 to 1200 K), and tungsten (4 to 3000 K).

16495. Jesch, R. L., **Repeatability of SMA coaxial connectors,** *CPEM Digest*, pp. 103-104 (1976).

Key words: coaxial connectors; insertion loss; microwave; reflection coefficient magnitude; repeatability.

SMA connectors in three different configurations were investigated for variation of reflection coefficient magnitude and insertion loss for a given SMA connector connect-disconnect sequence. Repeatability measurements were taken over the frequency range of 2 to 18 GHz for reflection coefficient and over the frequency range of 2 to 12.4 GHz for insertion loss on the National Bureau of Standards' Automatic Network Analyzer. A sample of variation of reflection coefficient magnitude is given for one SMA connector configuration. This variation was much smaller than was expected for SMA connectors.

16496. Jespersen, J. L., **A survey of time and frequency dissemination techniques,** *Proc. 24th Annual Frequency Control Symp., Atlantic City, NJ, Apr. 27-29, 1970*, pp. 322-324 (U.S. Army Electronics Command, Ft. Monmouth, NJ, 1970).

Key words: broadcast; communication; frequency; ratio; synchronization; time.

There are a number of common elements which characterize most time dissemination systems. Among the more important are: accuracy, repeatability, coverage, possibilities for improvement, cost to establish and maintain, ambiguity, time required to obtain answer, ease of use, and cost to the user. At the present time, there does not appear to be any single system which incorporates all of the desired characteristics. The relative importance of these characteristics varies from one user to the next and the kind of tradeoff that one user is willing to make is not a suitable tradeoff for another. Some of the systems such as WWV, were built specifically for the purpose of time and frequency dissemination while others such as TV have considerable potential. These systems and others will be discussed and compared with reference to the characterizing elements enumerated earlier, and some unresolved problems for the future will be considered.

16497. Johnson, W. L., McNeil, J. R., Collins, G. J., Persson, K. B., **CW laser action in the blue-green spectral region from Ag II,** *Appl. Phys. Lett.* **29,** No. 2, 101-102 (July 15, 1976).

Key words: charge transfer; lasers; sputtering; visible.

We have observed 18 cw laser transitions in Ne-Ag mixtures spanning the wavelength region from 408.6 to 585.2 nm. The upper laser levels of Ag II are judged to be pumped by a charge-transfer reaction between a ground-state neon ion and a ground-state Ag I atom resulting in simultaneous ionization and excitation of the silver atom. Output characteristics of the Ag II laser transitions as a function of neon pressure and discharge current are presented. The two strongest transitions are 478.8 and 502.7 nm in the blue and green, respectively.

16498. Kamper, R. A., **RF applications of the Josephson effect,** *Microwave J.* **19,** No. 4, 39-41, 52 (Apr. 1976).

Key words: high frequency; infrared; Josephson effect; measurements; superconductivity.

This paper reviews progress to date in applying the Josephson effect to microwave detectors, mixers, parametric amplifiers, and measuring systems.

16499. Kanda, M., **An error analysis for absolute flux density measurements of Cassiopeia A,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 3, 173-182 (Sept. 1976).

Key words: accuracy; antenna; calibration; Cassiopeia A; error analysis; flux density; G/T (system gain/system noise temperature); ground station; radio star.

An error analysis for absolute flux density measurements of Cas A is discussed. The lower-bound quadrature-accumulation error for state-of-the-art measurements of the absolute flux density of Cas A around 7 GHz is estimated to be 1.71 percent for 3σ limits. The corresponding practicable error for the careful but not state-of-the-art measurements is estimated to be 4.46 percent for 3σ limits.

16500. Kanda, M., Larson, T. R., **Stability of silicon avalanche noise diodes at K and K_a bands,** *CPEM Digest*, pp. 215-217 (1976).

Key words: silicon avalanche diode; solid state noise source; stability.

A statistical analysis is given for the stability of silicon avalanche noise diodes at K and K_a bands. A brief discussion of a statistical measure for stability and the measurement techniques are given. Cross-correlation coefficients of output noise from the noise diodes and their environmental factors are evaluated in order to examine the causes of the observed instabilities of noise diodes.

16501. Komarek, E. L., **An automated broadband system for measurement of one-port microwave parameters,** *CPEM Digest*, pp. 167-170 (1976).

Key words: application of six-port junction concept; automated measurements; broadband measurements; microwave measurements; microwave power measurements; one-port parameters; six-port junction.

A broadband measurement system has been implemented for determining microwave parameters of one-port devices in the 1-18 GHz frequency range using the six-port junction concept and automation techniques. Although not complete, performance evaluation results show that the system compares favorably with other automated and manually operated measurement methods.

16502. Krauss, M., **Analysis of NH spectrum,** (Proc. IAU Colloq. No. 25, Greenbelt, MD, Oct. 28-Nov. 1, 1974), Paper in *NASA SP-393, The Study of Comets*, B. Donn, M. Mumma, W. Jackson, M. A. Hearn, and R. Harrington, Eds., Part 2, pp. 848-852 (Scientific and Technical Information Office, National Aeronautics and Space Administration, Washington, DC, 1976).

Key words: comet; electric-dipole transition; excited states; NH; spin-orbit coupling; transition probability.

The NH cometary spectra is examined within the context of the radiation equilibrium model. The total fluorescent rate for the $A^3\Pi$-$X^3\Sigma^-$ transition is found to be less than 10 $^2S^1$ and the rate for the $c^1\pi$ $^1\Delta$ transition is estimated to be comparable. A semiempirical calculation of the spin-orbit induced $a^1\Delta$-$X^1\Sigma^-$ transition finds the rate to be about 5 S^1. Any $^1\Delta$ NH formed in an initial photodissociation would radiate to the ground state before it can be excited. The photochemical origin of the NH radical cannot be deduced from the fluorescence spectra.

16503. Kuriyama, M., Boettinger, W. J., Burdette, H. E., **X-ray topographic observations of magnetic domains in Czochralski-grown nickel single crystals in anomalous transmission geometry,** *J. Appl. Phys.* **47,** No. 11, 5064-5068 (Nov. 1976).

Key words: crystal perfection; Czochralski growth; domain walls; magnetic domains; nickel single crystals; surface reflection topography; transmission topography; x-ray diffraction topography.

Ferromagnetic domain walls are observed in large Czochralski-grown nickel single crystals by x-ray double crystal diffraction topography in the surface reflection geometry as well as in the transmission geometry. The images of magnetic domain walls in surface reflection topographs possess almost as good contrast as those in the transmission topographs, and even reveal fine detailed structures distinctly. Based on preliminary arguments, the images observed in the surface reflection topographs are attributed to 180° walls intersecting with the crystal surface obliquely, while the transmission topographs easily image 71° and 109° walls in the interior of the crystals.

16504. Larsen, N. T., **A new self-balancing DC-substitution RF power meter,** *CPEM Digest*, pp. 203-205 (1976).

Key words: bolometer; microwave; power measurement.

Problems intrinsic in self-balancing Wheatstone bridges have led to the development of a new dc substitution microwave power meter. The new instrument allows four-terminal measurement of bolometer resistance and affords improved accuracy and lower noise at a lower cost than earlier instruments. Measurement errors due to imperfect behavior of the servo system are typically less than 0.01 percent.

16505. Ledbetter, H. M., Weston, W. F., **Low-temperature elastic properties of some copper-nickel alloys,** *Proc. IEEE Symp. on Ultrasonics, Los Angeles, CA, Sept. 22-24, 1975*, pp. 623-627 (IEEE, New York, NY, 1976).

Key words: bulk modulus; compressibility; copper; copper alloys; elastic constants; Poisson ratio; pulse-echo method; resonance method; shear modulus; sound velocity; Young's modulus.

The polycrystalline elastic properties of Cu, Cu-10 Ni, and Cu-30 Ni were determined between room temperature and liquid-helium temperature using both pulse-echo (10 MHz) and resonance (60 kHz) methods. The temperature dependence of all three materials is regular. The composition dependence of the elastic constants is reviewed and new composition dependences are proposed.

16506. Lias, S. G., Ausloos, P., Horvath, Z., **Charge transfer reactions in alkane and cycloalkane systems. Estimated ionization potentials,** *Int. J. Chem. Kinet.* **VIII,** 725-739 (1976).

Key words: alkane ions; alkanes; charge transfer; ion-cyclotron resonance; ion-molecule reactions; ionization potentials; rate constants.

Rate constants of charge transfer reactions k_{CT}, involving C_3-C_9 alkanes and cycloalkanes, have been determined in an ion cyclotron resonance mass spectrometer. The rate constants are significantly lower than the corresponding rate constants for collision when the reaction is less than about 0.5 eV exothermic for linear alkane ions, or less than about 0.2 eV exothermic for cycloalkane ions. In this region of low reaction efficiency, the efficiency of reaction with linear or branched alkanes seems to depend primarily on reaction exothermicity. (The efficiencies of reaction of a given ion with cyclic alkanes also depend on ΔH_{rn}, but are higher than for reactions with other compounds.) Although the lowered reaction efficiencies probably result, at least in part, from unfavorable Franck-Condon factors in the energy range near the ionization onset, quantitative correlations between reaction efficiency and estimated relative Fránck-Condon factors were not observed. When the enthalpy of reaction is small (less than about -0.15 eV), it is seen that the reverse charge transfer can also occur, and equilibrium is established under the condition of these experiments. From the observed equilibrium constants, values for the standard free energy change are derived, and assuming that ΔS is small for electron transfer equilibria, values of ΔH_{rn} are estimated. In the case of the equilibria involving cyclohexane ion, these values of ΔH_{rn} lead to estimates of the ionization potentials of methylcyclopentane, 3-methylpentane, *n*-octane, 2,2-dimethylbutane, and 2,3-dimethylbutane, which are lower than the ionization potentials of cyclohexane, that is, < 9.88 eV, although all these compounds had previously been reported to have ionization potentials above 10.03 eV. That the ionization potentials are indeed lower than 10.03 eV is confirmed by determining the quantum yields of ionization with 10.03-eV photons.

It is pointed out that the conclusions reached here apparently also apply to the charge transfer reactions of alkane ions in the liquid phase.

16507. Lightbody, J. W., Jr., Penner, S., Fivozinsky, S. P., Hallowell, P. L., Crannell, H., **Electron scattering from vibrational nuclei,** *Phys. Rev. C* **14,** No. 3, 952-964 (Sept. 1976).

Key words: anharmonicities; branching ratio; charge distribution; electron scattering; quadrupole phonons; vibrational nuclei.

We present electron scattering form factors for the ground states and several low energy quadrupole excitations of the nuclei ^{52}Cr, ^{110}Pd, ^{114}Cd, and ^{116}Sn. For ^{116}Sn we also present the form factor for the lowest octupole excitation. From these data we derive ground state charge distribution parameters as well as $B(EL)$ values. We attempt to interpret the observed 2^+ states as the one- and two-phonon states of an anharmonic vibrational model. Predictions are made for the electromagnetic decay branching ratios and excited state electric quadrupole moments.

16508. Lightbody, J. W., Jr., **Electron scattering from one- and two-phonon vibrational states,** *Physics Lett.* **38B,** No. 7, 475-479 (Apr. 3, 1972).

Key words: admixture; anharmonicities; branching ratios; electron scattering; phonons; reorientation effect.

Admixtures of one- and two-phonon states are required to fit (e, e′) form factors for the lowest two 2^+ states in several even-even vibrational nuclei. These anharmonic wave functions correctly reproduce radiative branching ratios and excited state quadrupole moments.

16509. Little, W., Wakefield, J., Heim, L., Alfred, C., Zapf, T., Manney, C., **An NBS developed automatic network analyzer,** *CPEM Digest*, pp. 130-133 (1976).

Key words: attenuation; automated; bolometer mount efficiency; measurements; network analyzer; phase; reflection coefficient.

This paper describes a precision automated measurement system that has been under development at NBS since 1971 for the frequency range of 0.1 to 12.4 GHz. The system has been designed to measure attenuation, phase shift, reflection coefficient, and bolometer mount efficiency with accuracy as good as or better than can be achieved with present state-of-the-art manual measurement techniques (approximately an order of magnitude better than commercially available ANA's). The paper also presents recent measurement results that have been achieved with the system.

16510. Little, W. E., Yates, B. C., **Reflection coefficient standards for automated network analyzers,** *CPEM Digest*, pp. 128-129 (1976).

Key words: automatic; broad frequency; equations; network analyzers; open circuit reflection coefficient; short circuit; standards.

This paper describes the development and use of broad frequency band reflection coefficient standards for rectangular and coaxial waveguide. Equations for both the magnitude and phase angle of the reflection coefficient of "off-set" short circuits are presented so that these values can be calculated as a function of frequency. An equation for the phase angle of the coaxial "open circuit" reflection coefficient is given in terms of the open circuit capacitance and frequency. Also, an empirical equation is given that allows an estimate of the "open circuit" reflection coefficient magnitude.

16511. McNeil, J. R., Johnson, W. L., Collins, G. G., Persson, K. B., **Ultraviolet laser action in He-Ag and Ne-Ag mixtures,** *Appl. Phys. Lett.* **29,** No. 3, 172-174 (Aug. 1, 1976).

Key words: He-Ag and Ne-Ag mixtures; laser action; ultraviolet laser action.

We report eight new laser transitions which span the wavelength region from 220 to 400 nm. Six of the ultraviolet transitions are observed in Ne-Ag mixtures and two are observed in He-Ag mixtures. The 227.8- and 224.3-nm laser transitions of Ag II, $5d^3D_2$-$5p^3P_1^0$ and $5d^1S_0$-$5p^1P_1^0$ respectively, are the shortest-wavelength cw laser transitions reported in the literature to date. Output characteristics of the ultraviolet laser transitions as a function of buffer gas pressure and discharge current are presented. The strongest laser transition $4d^85s^2\ ^1G_4 \rightarrow 4d^95p^3F_3^0$, at 318.1 nm, provides single-line peak output power of 350 mW. The output power does not appear to saturate at the limit of our input current, 50 A.

16512. Meijer, P. H. E., Lockhart, R. G., Niemeijer, T., **Influence of crystallographic displacement and *g*-factors on the ground state of cerous magnesium nitrate,** *Solid State Commun.* **18,** No. 4, 473-474 (1976).

Key words: cerous magnesium nitrate; crystal structure; *g*-factors; ground state energy; Luttinger-Tisza method; translation vectors.

Since the thermodynamic properties of cerous magnesium nitrate play such an important role in low temperature physics we computed the influence of all variations still possible under the given set of known data: Small variation in the lattice structure, in particular the displacement of the center plane, small variations of the *g*-factor and the combination thereof.

16513. Mies, F. H., **Polarization of OH radiation,** (Proc. IAU Colloq. No. 25, Greenbelt, MD, Oct. 28-Nov. 1, 1974), Paper in *NASA SP-393, The Study of Comets*, B. Donn, M. Mumma, W. Jackson, M. A. Hearn, and R. Harrington, Eds., Part 2, pp. 843-847 (Scientific and Technical Information Office, National Aeronautics and Space Administration, Washington, DC, 1976).

Key words: comets; fluorescence; OH-18-cm radiation; optical pumping; polarization.

In the absence of collisions, optical pumping of cometary OH by solar ultraviolet radiation determines the relative population of OH molecules in the Λ-doubled levels of the $^2\Pi_{3/2}$ ground state, and also produces an alignment of the magnetic sublevels along the axis of the incident solar radiation. This results in a linear polarization of both the u.v. fluorescent spectrum and the 18-cm OH radiowave spectrum.

16514. Murphey, W. M., Sherr, T. S., Bennett, C. A., **Societal risk approach to safeguards design and evaluation,** (Proc. 16th Annual Meeting Institute of Nuclear Materials Management, Inc., New Orleans, LA, June 18-20, 1975), Paper in *Nuclear Materials Management* **IV,** No. III, 588-606 (1975).

Key words: nuclear materials safeguards; safeguards evaluation; safeguards system design; societal risk.

A comprehensive rationale for safeguards design and evaluation, and a framework for continuing systematic assessment of the system's effectiveness and efficient allocation of available safeguards resources so as to provide a balanced protection has been developed. The general objective of safeguards has been stated as: "to achieve a level of protection against ... [willful actions involving the possession of nuclear materials or the sabotage of nuclear facilities] that insures against a significant increase in the overall risk of death, injury, or property damage to the public from other causes beyond the control of the individual." Consistent with this objective, the societal risk approach was chosen as the basis for designing and evaluating the safeguards system. The approach considers the frequency (or likelihood) of occurrence of an antisocial act involving nuclear materials or facilities and the magnitude of the effects on society should such an act be successfully perpetrated. The analysis starts with the identification of the set of illegitimate final acts, or "events," which involve nuclear materials or nuclear facilities. These events are used as a basis for identifying the adversary action sequences that could produce the final events, and as a basis for considering the consequences to the public. The paper presents a summary of the societal risk approach, considerations relating to frequency of attempt, an adversary action tree approach to analysis of adversary activities, the structure of the safeguards system implied by the adversary actions, and implications relating to safeguards system design and evaluation arising from the societal risk approach.

16515. Okabe, H., **Photochemistry,** Paper in *Encyclopedia of Chemistry Uses (Utet Sansoni Edizioni Scientifiche)*, **V,** 610-615 (Firenze, Italy, 1976).

Key words: bond energy; chain reaction; determination of photochemical mechanism; flash photolysis; intermittent illumination; photochemical principles; photochemical reaction of atoms and molecules; photochemistry in the atmosphere; photochemistry of air pollution; primary and secondary photochemical processes.

The principles and processes of photochemistry are described at an elementary level. The importance of quantum yield measurement is emphasized. Main topics covered in this article are chain reaction, flash photolysis, effect of intermittent illumination, examples of photochemical reaction in atoms and molecules, application of photochemistry for the measurement of bond energy, photochemistry in the atmosphere and photochemistry of air pollution.

16516. Reeve, G. R., Arthur, M. G., **A standard percent modulation measurement system,** *CPEM Digest*, pp. 165-166 (1976).

Key words: amplitude modulation; instrument landing system; modulation measurements; modulation meter; percent modulation.

This paper describes a precision percent modulation measurement system constructed by the Electromagnetics Division, National Bureau of Standards, for calibration of secondary standards for instrument landing system (ILS) generators and meters. A description of the electronics is presented along with the estimated measurement uncertainty.

16517. Reite, M., Zimmerman, J. E., Edrich, J., Zimmerman, J., **The human magnetoencephalogram: Some EEG and related correlations,** *Electroencephalogr. Clin. Neurophysiol.* **40,** 59-66 (1976).

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Key words: magnetic evoked response; magnetoencephalography.

Simultaneous magnetoencephalographic (MEG) and electroencephalographic (EEG) data were recorded from four normal adults. Spectral analysis suggested that the MEG and EEG data were produced by similar but nonidentical generator systems; the MEG recorded here may be generated by intrasulcal cortex. A magnetic averaged evoked response to flash was recorded in one subject, consisting of a waveform similar to and phase-coherent with the simultaneous EEG averaged evoked response, such that cortical negativity was correlated with a magnetic field directed into the scalp.

16518. Riad, S. M., Nahman, N. S., **Application of the homomorphic deconvolution for the separation of TDR signals occurring in overlapping time windows,** *CPEM Digest*, pp. 27-29 (1976).

Key words: homomorphic deconvolution; time domain measurements; time domain reflectometry.

The homomorphic transformation is used to separate a time domain reflectometry (TDR) signal into its rapidly and slowly varying components, respectively. The separation (deconvolution) technique is successful in the case where the multiple reflections cannot be viewed in nonoverlapping time windows as is required by the conventional TDR method.

16519. Ries, F. X., **An international intercomparison of voltage standards at 1 GHz in coaxial transmission line,** *IEEE Trans. Instrum. Meas.* **IM-25,** No. 3, 254-255 (Sept. 1976).

Key words: electrical measurements; radio frequency; voltage measurements.

The results of an International Intercomparison of RF voltage at 1 GHz is described. This comparison was sponsored by the High Frequency Working Group of the Comité Consultatif d'Eléctricité (CCE) at the Bureau International des Poids et Mesures (BIPM). Differences between values reported by the five participating laboratories fell within the total uncertainties given by these laboratories. The estimated limits of uncertainty given by the laboratories varied from a few tenths to several percent.

16520. Risley, A. S., Shoaf, J. H., Ashley, J. R., **Frequency stabilization of *X*-band sources for use in frequency synthesis into the infrared,** *IEEE Trans. Instrum. Meas.* **IM-23,** No. 3, 187-195 (Sept. 1974).

Key words: cavity stabilization; frequency multiplication; frequency stability; frequency synthesis; Gunn oscillator; infrared; injection stabilization; klystron; *X band.*

An *X*-band source of excellent frequency stability is needed in infrared frequency multiplication of high order. Such a source has been used in frequency multiplication by a factor of 401 using a point-contact Josephson junction as a frequency multiplier and mixer. Noise data on three *X*-band systems are reported. Two of these systems use klystrons as the source of *X*-band power; the other uses a Gunn oscillator. Each of these three systems employs both cavity and injection stabilization. Injection stabilization, using a quartz-oscillator-driven multiplier chain, provides the second-to-second and minute-to-minute stability needed for the Josephson junction experiment. To our knowledge, this is the first published noise data where cavity and injection stabilization are simultaneously employed. The quality of the best system reported here is much better—both around 1 Hz from the carrier and around 50 kHz from the carrier—than the source used to multiply by a factor of 401 to 3.8 THz.

16521. Rockar, E. M., Forman, R. A., **Polarized luminescence from MgO:Cr^{3+},** *Phys. Rev. B* **14,** No. 8, 3621-3629 (Oct. 15, 1976).

Key words: chromium 3+; crystal vacancies; cubic crystals; depolarization; impurity compensation; luminescence; magnesium oxide; MgO; optical properties; polarized luminescence; symmetry; transition metal ions.

MgO:Cr^{3+} has been used as a model system to study the general case of polarized luminescence from transition-metal impurities in cubic materials. Using polarized exciting light, information can be obtained about the site symmetries of the impurities as well as the dipole character of the absorbing and emitting levels. The data presented are in substantial agreement with previous studies on the line emission spectra of MgO:Cr^{3+} obtained by other techniques. Careful experimental procedures to avoid artifacts are detailed. Experimental values for the polarizations are always significantly smaller than those predicted by theory. A dependence of polarization with chromium concentration was also noted. Probable causes for these effects are discussed.

16522. Roder, H. M., **The heats of transition of solid ethane,** *J. Chem. Phys.* **65,** No. 4, 1371-1373 (Aug. 15, 1976).

Key words: ethane; heat capacity; heat of fusion; heat of transition; transition temperature; triple point.

The existence of a solid-solid transition in ethane is now generally accepted. A value for the heat of transition, 2437 ± 35 J/mol at 89.774 K, together with a new value for the heat of fusion, 279 ± 6 J/mol at 90.337 K, is reported in this work. The sum of the new values is in excellent agreement with the earlier measurements, provided that the heat required to raise the temperature of the solid between transitions is included. The transition temperatures are in agreement with the most recent determinations of other authors.

16523. Ruff, A. W., **Deformation studies at sliding wear tracks in iron,** *Wear* **40,** 59-74 (1976).

Key words: electron channeling; iron; metals; plastic deformation; surfaces; wear.

Determinations have been made of strains on the surface and subsurface of specimens of high purity iron after different distances of sliding wear. The method involved the measurement of loss of intensity (contrast) of particular electron channeling lines obtained from small selected areas near the wear track. A calibration specimen, deformed plastically to a range of strain values, was used to relate the channeling line contrast loss to plastic strain. Strain maps lateral to the wear track and below the original surface were obtained after removing controlled thicknesses of iron by electropolishing. In all cases the maximum strain was found at the track center location at the surface and the strains decreased steadily with depth below the track. With a 50 g load the strains vanished at about 40 μm depth. Significant strains were found to exist outside the wear track boundaries. There was no indication of a soft or less-hardened surface layer in any of the specimens studied.

16524. Sanders, D. M., Blackburn, D. H., Haller, W. K., **A high-temperature transpiration apparatus for study of viscous, incongruently vaporizing glass melts,** *J. Am. Ceramic Soc.* **59,** No. 7-8, 366-368 (Aug. 1976).

Key words: glass; incongruent vaporization; transpiration; vapor density.

The vapor density of sodium over a well-stirred soda-lime-silica glass melt was measured using a newly developed transpiration apparatus. This apparatus uses intense stirring action to

produce fresh surfaces throughout the measurement. This feature is necessary to prevent the formation of depleted layers formed by preferential vaporization of one of the glass components. The apparatus design and operating characteristics are discussed.

16525. Schleter, J. C., **A decision structure for a State safeguards system,** (Proc. Symp. Safeguarding Nuclear Materials, Vienna, Austria, Oct. 20-24, 1975), Paper in *Safeguarding Nuclear Materials*, **I,** 199-213 (International Atomic Energy Agency, Vienna, Austria, 1976).

Key words: decision structure; information system; nuclear material diversion; nuclear materials; safeguards; safeguards information system.

An effective structure to direct safeguards decisions within a State's safeguards system is vital in order to minimize the possibility of illicit diversion of nuclear material. In a State each plant usually has some form of information system in operation but it is generally plant specific and often is directed only to management functions. The systematic study, discussed in this paper, is aimed at developing a more comprehensive Safeguards Information System (SIS). The concepts used are applicable to any State's safeguards system. Decision makers are identified and classified. General safeguards and operational tasks are defined for each and, based on these, information sources are identified. The flow structure for information is specified to enable safeguards decision makers to function properly. Concepts used to characterize the SIS and the associated decision structure are discussed.

16526. Schleter, J. C., A **decision structure for plant safeguards,** (Proc. 16th Annual Meeting Institute of Nuclear Materials Management, Inc., New Orleans, LA, June 18-20, 1975), Paper in *Nuclear Materials Management* **IV,** No. III, 406-430 (1975).

Key words: decision makers; decision structure; information flows; nuclear material information systems; nuclear materials safeguards; safeguards.

A systematic study has been performed to determine the information necessary for meaningful safeguards decisions. The resulting Safeguards Information System (SIS) encompasses all decision makers, in general terms, from those at ERDA Headquarters to the operator on the process line. Only decision makers within the plant are considered in this paper. The basic premises and steps employed in developing SIS are described. These include rapid two-level reporting of abnormal situations, identification of the safeguards decision makers, deduction of safeguards information generated and abnormal situations observed by each as a result of operational tasks, and to whom the information is transmitted. The content of information flowing to and from each decision maker from all sources is established and assurance is given that each decision maker receives the necessary information and that extraneous information is held to a minimum. By means of the analysis, a decision structure for safeguards becomes apparent, the decision capability of each decision maker can be specified, and the sources and flows of information necessary for meaningful safeguards decisions can be identified. The application of the general SIS, to serve as the basis of a plant-specific SIS, is also considered.

16527. Siegwarth, J. D., Lawless, W. N., Morrow, A. J., **Dielectric and thermal properties of $Pb_2Nb_2O_7$ at low temperature,** *J. Appl. Phys.* **47,** No. 9, 3789-3791 (Sept. 1976).

Key words: antiferroelectric; dielectric constant; heat capacity; lead pyroniobate; low temperature; polarization.

Measurements of the dielectric constant, polarization, zero-field specific heat, and field-dependent specific heat of polycrystalline $Pb_2Nb_2O_7$ at low temperatures are reported. No evidence for a phase transition at 15 K was found, contrary to previous suggestions of an antiferroelectric transition at 15 K based on dielectric data. The peak in the dielectric constant appears to be due to relaxation phenomena.

16528. Smith, E. W., Giraud, M., Cooper, J., **A semiclassical theory for spectral line broadening in molecules,** *J. Chem. Phys.* **65,** No. 4, 1256-1267 (Aug. 15, 1976).

Key words: *ab initio* potentials; atom-molecule interactions; curved classical trajectories; HCl, CO, CO_2 with He, Ar; rotation-vibration spectra; semiclassical *S*-matrix; spectral line broadening.

A semiclassical *S*-matrix theory is developed and applied to spectral line broadening in linear molecules perturbed by atoms. This theory uses curved classical trajectories determined by the isotropic part of the atom-molecule interaction and the *S*-matrix is treated to all orders in the interaction. Numerical calculations can be made rather easily even for high quantum numbers. The theory is least accurate for very low quantum numbers, but even then calculations agree to within 10 percent with close coupling results where comparisons could be made. Comparisons were also made with other theoretical approaches using model potentials and with experiments using *ab initio* potential surfaces.

16529. Sorensen, C. M., Fickett, F. R., Mockler, R. C., O'Sullivan, W. J., Scott, J. F., **On lysozyme as a possible high-temperature superconductor,** *J. Phys. C: Solid State Phys. Letter to Ed.* **9,** L251-L254 (1976).

Key words: diamagnetism; light scattering; molecular diffusion; organic molecule; superconductor; susceptibility.

Intensity autocorrelation measurements of the diffusion constant of lysozyme molecules in aqueous solutions as a function of applied magnetic field reveal no evidence of the cooperative behavior proposed by Ahmed, Calderwood, Fröhlich and Smith to explain their observation of a large peak in the diamagnetic susceptibility of lysozyme at an applied field of 600 Oe. Careful susceptibility measurements using a SQUID system show that the diamagnetic susceptibility of lysozyme and lysozyme solutions is constant up to our maximum field of 720 Oe.

16530. Sugar, J. R., **A VOR audiofrequency standard signal source based on digital waveform synthesis,** *CPEM Digest*, pp. 72-73 (1976).

Key words: aircraft navigation systems; digital frequency synthesis; national standards; precision audiofrequency signal generation; precision FM signal generation; precision phase angle generation; radio navigation; VOR.

This unit generates three highly accurate audio signals for use in calibrating the working standards for the calibration of VHF omnirange (VOR) aircraft navigation systems. The three signals are two 30 Hz sine waves and a 9960 Hz carrier, frequency modulated by a 30 Hz sine wave. The phase of one of the 30 Hz signals is adjustable in .01° steps relative to the other two signals. The zero-crossing points of all three signals are accurate to approximately .01° relative to 30 Hz. In order to achieve this level of accuracy the signals are generated digitally and then converted to analog form. A substantial reduction in the required size of read-only-memory for storing the required digital functions is achieved by storing the differences rather than the functions themselves. Error-checking circuits and built-in-test circuits are incorporated to provide an immediate indication of malfunction of the digital circuits.

16531. Tobler, R. L., **Fatigue crack growth and J-integral fracture parameters of Ti-6A1-4V at ambient and cryogenic temperatures,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 601*, 346-370 (1976).

Key words: fatigue crack propagation; fracture toughness; J-integral; low temperature tests; titanium alloys.

Fatigue crack propagation and fracture parameters for 2.03-cm-thick compact specimens of an extra-low-interstitial Ti-6A1-4V alloy were measured at temperatures between 296 K (70 °F) and 4 K (− 453 °F). Plane-strain linear-elastic and J-integral fracture toughness test results were in good agreement: the K_{1c} values for this alloy decreased from 105 MN/m$^{3/2}$ at room temperature to 54 MN/m$^{3/2}$ at 4 K, and a ductile-to-brittle fracture transition occurred in the range 125 to 76 K (− 235 to − 323 °F). Despite this transition, the fatigue crack growth rates *(da/dN)* of this alloy remained temperature insensitive over the entire ambient-to-cryogenic range. These fatigue and fracture results are compared with data previously reported for a normal-interstitial Ti-6A1-4V alloy.

16532. Truhlar, D. G., Brandt, M. A., **Close-coupling calculations of differential cross sections for elastic scattering and rotational excitation of hydrogen molecules by electrons at 10 and 40 eV,** *J. Chem. Phys.* **65,** No. 8, 3092-3101 (Oct. 15, 1976).

Key words: close-coupling calculations; cross sections; differential cross sections; elastic scattering; electron scattering; exchange (of electrons); hydrogen molecules; inelastic scattering; momentum transfer; polarization (of charge clouds); rotational excitation; scattering theory.

We have performed close-coupling calculations including two rotational states for electron scattering by hydrogen molecules at 10 and 40 eV impact energies. The effective interaction potential was taken as a sum of the static, exchange, and polarization interactions. With no empirical parameters, good agreement with experiments was obtained for the angle dependences and magnitudes of the differential cross sections for both pure elastic scattering and rotational excitation except that there are discrepancies in the elastic scattering at small scattering angles where the experiments are least reliable. Variations of the forms of the exchange and polarization potentials were examined and the effect on the cross sections was small.

16533. Truhlar, D. G., Brandt, M. A., Chutjian, A., Srivastava, S. K., Trajmar, S., **Electron scattering by N_2 at 5 and 10 eV: Rotational-vibrational close-coupling calculations and crossed beam studies of vibrational excitation,** *J. Chem. Phys.* **65,** No. 8, 2962-2969 (Oct. 15, 1976).

Key words: close-coupling calculations; crossed beams; cross sections; differential cross sections; electron scattering; inelastic scattering; nitrogen molecules; polarization potential; scattering; static potential; vibrational excitation.

The ratios of differential cross sections for excitation of the first excited vibrational state to differential cross sections for elastic scattering of N_2 have been measured at scattering angles ranging from 20° to 135° at 5 and 10 eV impact energies. Using previously measured and normalized elastic differential cross sections for N_2, the ratios have been converted to inelastic cross sections. Laboratory-frame close-coupling calculations using a four-state vibrational-rotational basis set and an effective interaction potential developed previously are reported at both energies. It is shown that the four-state treatment of this potential scattering model can account for the approximate magnitude and the qualitative behavior of the cross sections, but there are some significant quantitative differences between theory and experiment.

16534. Wacker, P. F., Bowman, R. R., **Quantifying hazardous electromagnetic fields: Scientific basis and practical considerations,** *IEEE Trans. Microwave Theory Tech.* **MTT-19,** No. 2, 178-187 (Feb. 1971).

Key words: nonionizing fields; probes; radiation.

As commonly recognized, the problem of quantifying hazardous electromagnetic (EM) fields is difficult and has not yet been satisfactorily solved. Essentially, this is because people are often exposed to emanations from powerful sources of EM fields at points close to the sources and at points where arbitrary polarization and multipath interference exist. However, the accepted concepts, standards, and most measuring instrumentation are based on simple plane-wave field propagation and so are inadequate for complicated fields.

The complications and problems of quantifying hazardous EM fields involving source-subject coupling, reactive near-field components, multipath components, and arbitrary polarization are examined in some detail. General discussion of dosimetric measurements and hazard survey measurements is given, and also some basic considerations for the design of field probes for these measurements. Recommendations are given for suitable parameters for quantifying complicated EM fields, and essential and desirable characteristics for hazard survey meters are stated. Several recently designed hazard survey probes are capable of measuring these recommended parameters in many complicated fields of interest, and improved instruments are anticipated.

16535. Yokel, F. Y., **A performance standard for foundations and excavations,** *Civil Eng.* **47,** No. 10, 80-81 (Oct. 1976).

Key words: buildings (codes); excavation; foundations; geotechnical engineering; standards.

Work is now in progress on the preparation of a national standard for foundations and excavations under the ASCE-COS "Committee for Foundation and Excavation Standards," (CFES).

16536. Goodwin, K. E., Maltese, M. D. K., Schleter, J. C., **Diversion path analysis handbook. Volume II. Example,** 225 pages (Division of Safeguards and Security, U.S. Energy Research and Development Administration, Washington, DC, Oct. 1976).

Key words: analysis; diversion of nuclear materials; diversion path analysis; internal control system characterization; nuclear material safeguards; safeguards.

A hypothetical example illustrating the methodology given in Volume I of "The Diversion Path Analysis Handbook" is presented. The process, derived for the example, might be typical of the end of a fabricating process line where plutonium metal bars, originating in an earlier unspecified process step, are cut up and recast into buttons for long term storage. The process is intended to reflect typical actual practice, but in some cases, the parameters have been specially tailored so that as many features of DPA could be illustrated. The example is presented in the format recommended for use when documenting a DPA. It contains all of the basic components necessary for complete documentation and its use assures a common basis for intercomparisons of DPA's, both intra- and inter-plant. Volume II is divided into two parts—the workpaper documentation and the summary report. The former sets forth the bounds of the analysis, the information gathered, the characterization of the process, the specific diversion paths related to the process, and, finally, the results and findings, of the DPA. The summary report, made up of portions of sections already prepared for the workpapers is a concise statement of results and recommendations for management use.

16537. Evans, B. J., Swartzendruber, L. J., **Magnetic hyperfine field structure of iron Urushibara type catalysts,** (Proc. Annual 20th AIP Conf. on Magnetism and Magnetic Materials, San Francisco, CA, Dec. 3-6, 1974), Paper in *Magnetism and Magnetic Materials—1974*, C. D. Graham, Jr., G. H. Lander, and J. J. Rhyne, Eds., No. 24,391-393 (American Institute of Physics, New York, NY, 1975).

Key words: alloys; aluminum; catalysis; hydrogenation; iron; Mössbauer spectra; zinc.

We have utilized the Mössbauer effect to study the hyperfine field structure of iron Urushibara catalysts. The Mössbauer spectra of those catalysts prepared using zinc show that they consist of a mixture of magnetic and nonmagnetic Fe-Zn alloys. Both the magnetic field distribution in the magnetic phase and the relative amounts of magnetic and nonmagnetic phases depend on the Fe-Zn ratio used in the preparation of the catalyst. This dependence on Fe-Zn ratio is in contrast to iron Urushibara catalysts prepared using aluminum (and Raney iron type catalysts) in which the active phase is almost pure α-Fe, irrespective of the Fe-Al ratio. The activity of zinc prepared iron Urushibara catalysts for certain hydrogenation reactions is known to be greater than that of aluminum prepared iron Urushibara catalysts and the above results suggest a relationship between activity and the modification of the iron catalyst by alloyed zinc. The alloying behavior of the Fe-Zn particles may be analogous to that of the so-called bimetallic clusters observed in other alloy systems.

16538. Deslattes, R. D., Lamotte, M., Dewey, H. J., Keller, R. A., Freund, S. M., Ritter, J. J., Braun, W., Kurylo, M. J., **Isotopic enrichment in laser photochemistry,** (Proc. Second Int. Conf. Laser Spectroscopy, Megève, France, June 23-27, 1975), Lecture Notes in *Physics* **43,** pp. 296-303 (Springer-Verlag, New York, NY, 1975).

Key words: isotope separation; kinetics; lasers; photochemistry.

Laser technology has permitted more efficient study of the chemistry of molecules in excited states. The extent to which isotopic specificity is preserved in going from initial excitation to final product is a valuable diagnostic for excited state chemistry. This report summarizes initial results from several areas of investigation, each of which suggests that laser stimulation may offer more than simple rate enhancement.

16539. McCulloh, K. E., **Energetics and mechanisms of fragment ion formation in the photoionization of normal and deuterated water and ammonia,** *Int. J. Mass Spectrom. Ion Physics* **21,** 333-342 (1976).

Key words: ammonia; appearance potential; autoionization; deuterated species; enthalpy of formation; ionization potential; NH_2^+; OH^+; photoionization; predissociation; Rydberg states.

Fragment photoion yield curves have been obtained for OH^+ from H_2O at 215 and 298 K and for NH_2^+ from NH_3 at 160 and 298 K. The results indicate that for both molecules the initial rotational energy is completely available for fragmentation. Appearance potentials, corrected to 0 K, are 18.115 ± 0.008 eV for OH^+ from H_2O and 15.768 ± 0.004 eV for NH_2^+ from NH_3. Assuming zero excess energy at threshold, the values 309.0 ± 0.2 and 302.7 ± 0.1 kcal mol^{-1} are obtained for the standard enthalpies of formation of OH^+ and NH_2^+, respectively, leading to the derived ionization potentials $I(OH) = 12.995 \pm 0.009$ eV and $I(NH_2) = 11.17 \pm 0.05$ eV. The observed yield of OH^+ from H_2O deviates markedly from values calculated on the assumption that fragmentation occurs exclusively by predissociation from excited vibrational levels of H_2O^+ ($\tilde{B}\ ^2B_2$), suggesting that Rydberg series converging to these levels play an important role in OH^+ production. Appearance potentials for OD^+, NHD^+ and ND_2^+ are reported.

16540. Paule, R. C., **Mass spectrometric studies of Al_2O_3 vaporization processes,** *High Temp. Sci.* **8,** 257-266 (1976).

Key words: AlO_2; Al_2O_3; emissivity; evaporation coefficient; Langmuir vaporization; optical pyrometry; radiation heating; vapor pressures.

An investigation of the radiative and evaporative properties of Al_2O_3 samples has been made. These observed properties interact in a manner such that, upon melting, the rate of evaporation is observed to increase discontinuously. This phenomenon had previously been attributed to a change in the evaporation coefficient. The current investigation has shown that the evaporation coefficient for Al_2O_3 is constant and that the observed increase in vaporization is due to an increase in the temperature which, in turn, is due to a discontinuous increase in the emissivity. Relative vapor pressure measurements were also made in this study, and the reported existence of the vapor species AlO_2 was not confirmed. All other reported vapor species were confirmed.

16541. Ederer, D. L., **Erratum: Cross section profiles of resonances in the photoionization continuum of krypton and xenon (600-400 Å),** *Phys. Rev. A ERRATA* **14,** No. 5, 1936-1937 (1976).

Key words: cross section; inner-shell excitation; krypton; photoionization; vacuum ultraviolet; xenon.

Equation (4) in this paper is incorrect. It should read:

$$\sigma(E) = C(E) + (2\sigma_a q(\Gamma/2)(E - E_r) + \sigma_a(q^2 - 1)(\Gamma/2)^2)/(E - E_r)^2 + (\Gamma/2)^2$$

Unfortunately the incorrect form of the cross section was inadvertently used to transform the parameters from the Fano representation to the Shore representation, consequently, some of the parameter values listed in Tables I and II are incorrect. The corrected tables are shown. The change in some of the a_i's will slightly effect the cross-section profiles of the resonance shown in figs. 1 and 2.

16542. Hocken, R., Horowitz, M. A., Greer, S. C., **Critical anomaly in the dielectric constant of a nonpolar pure fluid,** *Phys. Rev. Lett.* **37,** No. 15, 964-967 (Oct. 11, 1976).

Key words: Clausius-Mossotti equation; critical phenomena; dielectric constant; sulfur hexafluoride.

We report measurements of changes in the dielectric constant ϵ of SF_6 along a near critical isochore. We find an anomalous increase in ϵ. The amplitude of the anomaly is about 10 times larger than the one predicted by current theories, which assume a constant polarizability.

16543. Plummer, E. W., **Interaction of single atoms with atomically defined surfaces,** (Proc. Conf. Applications of Field-Ion Microscopy to Physical Metallurgy and Corrosion, Georgia Institute of Technology, Atlanta, GA, May 15-17, 1968), Paper in *Physical Metallurgy and Corrosion*, R. F. Hochman, E. W. Müller and B. Ralph, Eds., pp. 371-389 (1968).

Key words: adatom; binding energy; field ion microscope; surface.

The role of the field ion microscope in surface studies is illustrated by reviewing briefly several unique experiments which have been conducted. These include experiments on work func-

tion, condensation, surface rearrangement and self diffusion, and atomic binding at the surface. The details of the experiment on atomic bonding of individual atoms on single crystal planes is considered in more detail to illustrate the capabilities of this technique for investigating the fundamental properties of the surface-adatom interaction on an atomically defined surface.

16544. Simiu, E., **Wind climate and failure risks,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST9, 1703-1707 (Sept. 1976).

Key words: buildings (codes); failure; probability distribution functions; reliability; structural engineering; wind (meteorology); wind pressure.

The relation is examined between risk of failure, degree of wind sensitivity, type of wind climate, and mean recurrence interval used in design. The results presented are based on the assumption, used in the ANSI A58.1 Standard, that the probabilistic behavior of extreme wind speeds is adequately modeled by distribution functions of the largest values, the parameters of which are estimated from the data consisting of the largest yearly wind speed for every year of record. These results show that a strong correlation exists between probability of failure and type of wind climate, as defined quantitatively by the parameters of the extreme wind distribution. All other relevant factors being equal, including the degree of sensitivity to wind, it was found that the probability of failure of a member may increase considerably as a function of type of wind climate. It is suggested that the effect of the type of climate, as defined in the paper, be taken into account in design.

16545. Simiu, E., Filliben, J. J., **Probability distributions of extreme wind speeds,** *J. Struct. Div. Proc. Am. Soc. Civil Eng.* **102,** No. ST9, 1861-1877 (Sept. 1976).

Key words: buildings (codes); hurricanes; probability distribution functions; reliability; risk; statistical analysis; storms; structural engineering; wind pressure; wind speed.

An automated technique is presented for determining an appropriate distributional model for the largest yearly wind speeds. With a view to assessing the validity of current probabilistic approaches to the definition of design wind speeds, this technique was used in a study of extreme wind speeds based on records taken at 20 U.S. weather stations. The following results were obtained: (1) At 83 percent of the stations not susceptible to experiencing hurricane-force winds, the series of the largest annual wind speeds were well fit by Type I probability distributions of the largest values; (2) the assumption that Type II distributions with $\gamma = 9$ are generally representative of such stations was not confirmed; (3) type I probability distributions do not appear to describe correctly the behavior of extreme winds in regions subjected to special winds, e.g., hurricanes; and (4) in such regions, 20-yr data samples may provide a misleading picture of extreme wind behavior.

16546. Page, C. H., **Torque on a bar magnet,** *Am. J. Phys.* **44,** No. 11, 1104-1105 (Nov. 1976).

Key words: magnet; magnetization; torque.

If all magnetic quantities are defined via fields, with no use of poles and with magnetic moment defined as the volume integral of magnetization, energy considerations yield the torque on a magnet immersed in a permeable fluid in an external field. Although the torque on a disk magnet is proportional to **B**, the torque on a needle magnet is proportional to $\mu_0\mathbf{H}$, as reported experimentally by Whitworth and Stopes-Roe. The experiment does not prove either A. E. Kennelly [J. Eng. Educ. **27,** 290 (1935)] or Sommerfeld to be right or wrong, but demonstrates that magnetic theory based on *poles* cannot be applied to *magnets,* and thereby strengthens the philosophy that electromagnetic theory should be based on fields.

16547. Snell, J. E., Kusuda, T., Didion, D. A., **Energy conservation in office buildings: Some United States examples,** *Proc. International CIB Symp. on Energy Conservation in the Built Environment, Watford, England, Apr. 6-8, 1976,* pp. 1-34 (International Council for Building Research, Studies and Documentation, Rotterdam, The Netherlands, 1976).

Key words: commercial buildings; energy conservation; energy consumption; Manchester office building; National Bureau of Standards; New York State offices; office buildings.

The purpose of this paper is to describe recent experience in the United States and, in particular, the National Bureau of Standards (NBS) with energy conservation in office buildings. The NBS, working in cooperation with the Energy Research and Development Administration (ERDA) and the General Services Administration (GSA), is evaluating the energy efficiency of a demonstration office building in Manchester, New Hampshire. NBS utilized its thermal performance computer program (NBSLD) to evaluate a variety of energy conservation design alternatives for this building. These results are described and the current status of the project is reported. The NBS has conducted studies of energy conservation potentials in its own buildings at the Gaithersburg, Maryland, site. These measures include operational as well as retrofit actions. The results of actual tests and computer evaluations of predicted performance are discussed. Overall savings in energy use (fuel oil, fuel gas, and purchased electricity) of 20 percent have been achieved. An additional 20 percent reduction in energy use is expected from planned retrofit, including use of computerized HVAC controls. The NBS also has been working with an ad hoc industry group, representing owners and managers of commercial buildings, toward the development of self-help guidelines these managers can use in achieving energy conservation retrofit cost-effectively in their own buildings. Data collected to date and current status of these activities are reported. Many post-war office buildings were designed and constructed which are inimical to present energy conserving criteria. The excessive use of glass and illumination prevailed, as well as inefficient, although first-cost inexpensive, HVAC systems. Controls for building illumination and space conditioning were often inadequate for energy conservation operations. Therefore, these areas represent major opportunities for energy conservation in existing, as well as new, office buildings in the U.S., and are the target of a major effort by NBS and the Federal Government in general.

16548. Marron, B., Fife, D., **Online systems—Techniques and services,** Chapter 5 in *Annual Review of Information Science and Technology,* M. E. Williams, Ed., **11,** 163-210 (American Society for Information Science, Washington, DC, 1976).

Key words: bibliographic information systems; computer technology; information storage and retrieval; interactive systems; online services; online systems.

The Annual Review of Information Science and Technology, published by the American Society for Information Science, reviews the contemporary trends, progress, and problems in the major areas of information science. This chapter on "Online Systems—Techniques and Services" is intended for Volume 11 to be published in September 1976, and reviews the literature of 1974 and 1975.

The first section treats computer technology, networks and communications, and software, with particular emphasis on the significance of these techniques for future online systems design. Next there is coverage of online services with detail on promo-

tion and pricing of services, use of multiple services, online services in libraries, retrieval of nonbibliographic information, and document delivery. The third section treats the user interface in online systems, especially the role of the intermediary, design criteria for user-oriented systems, user training, and interface standardization. Finally some issues and problems of online systems are discussed.

16549. Cali, J. P., **The NBS Standard Reference Materials program: An update,** *Anal. Chem.* **48,** No. 11, 802A-818A (Sept. 1976).

Key words: accuracy; measurement; measurement compatibility; National Bureau of Standards; reference materials; standard reference materials; Standard Reference Materials program.

Ten years ago, almost to the day, the National Bureau of Standards reported in *Analytical Chemistry* the status of its Standard Reference Materials program. In view of the NBS 75th anniversary of its founding coinciding, as it does, with our Nation's 200th Anniversary, it seems especially fitting that an update of that report be made. In this short 10-year period, more substantive changes have taken place than occurred over the first 60 years of the program's existence. It is the purpose of this report to recapitulate these events and to attempt to predict what the future holds in store.

16550. Kusuda, T., **Control of ventilation to conserve energy while maintaining acceptable indoor air quality,** (Proc. ASHRAE Symp. on Ventilation Control, Semiannual Meeting, Dallas, TX, Feb. 1-5, 1976), *ASHRAE Trans.* **82,** Part 1, 1169-1182 (American Society of Heating, Refrigerating and Air Conditioning Engineers, New York, NY, 1976).

Key words: air quality; intermittent operation; maximum allowable concentration of CO_2; New York City schools; ventilation.

Basic requirements of ventilation with respect to the undesirable increase of building air contaminants are discussed. A mathematical model for determining the increase of contaminants concentration with time was developed and verified by applying it to the observed CO_2 increases in the New York City School experiment. Equations, tables and graphs were developed for estimating the CO_2 buildup and possible energy saving obtainable by using intermittent operation of ventilation systems. It is concluded that, if properly implemented, intermittent operation of ventilation systems could reduce the energy requirement for heating the ventilating air by as much as 40 percent under typical design conditions.

16551. Cotton, I. W., Grubb, D. S., **Criteria for the evaluation of data communications services,** *Proc. Symp. IEEE Trends and Applications 1976: Computer Networks, Gaithersburg, MD, Nov. 17, 1976,* pp. 71-78 (Institute of Electrical and Electronics Engineers, New York, NY, 1976).

Key words: computer communications; computer networking; data communications; networks; performance requirements; telecommunications.

The quality of telecommunications services that are used as a means of interchanging information between information processing systems or between terminals and systems is determined by a number of parameters. This paper examines the following characteristics of telecommunications services: 1. Transfer Rate; 2. Availability; 3. Reliability; 4. Accuracy; 5. Channel Establishment Time; 6. Network Delay; 7. Line Turnaround Delay; 8. Transparency; 9. Security.

These parameters are all defined and their significance discussed.

16552. Engen, G. F., **Comments on "Practical analysis of reflectometers and power equation concepts",** *IEEE Trans. Instrum. Meas.* **IM-23,** No. 1, 104-105 (Mar. 1974).

Key words: power equation concepts; reflectometers.

Although an apparent objective of the cited paper is to yield additional insight into the power-equation concept, the reader is cautioned that the accompanying analysis is based more on intuitive concepts than mathematical rigor.

Some of the conclusions are, at most, only approximately true. These need to be identified and their associated errors evaluated if the requirements of careful metrology are to be satisfied.

In addition to the consideration of these questions, this correspondence also includes a more careful statement concerning the insensitivity of the power-equation methods to connector problems.

16553. Davis, R. M., **Systems of the 1980s—The U.S. perspective,** (Proc. Conf. Meeting XXXV on A Preview of the 1980s and Distributed Processing, Amsterdam, Holland, Nov. 18-20, 1975), *Document No. EC35, Session C,* pp. 27-43 (Diebold Europe S.A., Frankfurt, Germany, 1976).

Key words: automated reading technology; circuitry; computer applications; computer engineering; distributed systems; interface standards; memory technology; protocols.

Computer systems of the 1980s will be used in applications such as data acquisition and validation, recordkeeping, management information systems, real-time control, real-time monitoring, modeling, simulation, individualized services, scheduling, allocation, dispatching, and scientific and research investigations. These systems will serve primarily two sets of customers. One set is composed of large single organizations using computer systems to manage diversified activities and economic communities using computer systems to link members together. The second set will be individual users needing autonomous dedicated computer systems which can be interconnected to larger computer service networks or other individuals. The 1980s will see computer networks containing computers and computer modules of all sizes, independent memories and large variety of access terminal and automated input devices. However, the present lack of information controls, privacy safeguards, audit procedures, performance measures for real-time control systems, interface standards, software validation and documentation standards will have to be overcome to assure acceptability of the envisioned systems.

16554. Engen, G. F., Hudson, P. A., **International intercomparison of power standards at 3 GHz,** *IEEE Trans. Microwave Theory Tech.* **MTT-19,** No. 4, 411-413 (Apr. 1971).

Key words: bolometer mount; connector compatibility; directional coupler; interlaboratory standards.

An international intercomparison of microwave power at 3 GHz has recently been completed. This comparison was initiated at a meeting of the High Frequency Working Group of the Comite Consultatif d'Electricite (CCE) which met at the Bureau International des Poids et Mesures (BIPM) in May, 1965. At that time, the U.S. National Bureau of Standards (NBS) was designated as the pilot laboratory. The other laboratories, in order of their participation, are the following: for Canada, National Research Council (NRC); for the U.S.S.R., All-Union Research Institute of Metrology imeni D. I. Mendeleyev (V-NIIM); for the German Democratic Republic, Deutsches Amt für Messwesen und Warenprüfung (DAMW); and for Japan, the Electrotechnical Laboratory (ETL).

16555. Alperin, H. A., Rhyne, J. J., Pickart, S. J., **Neutron scattering from an amorphous ferrimagnet,** *Proc. Int. Conf. of Magnetism, Moscow, USSR, Aug. 22-28, 1973*, **IV,** 358-366 (International Union of Pure and Applied Physics, The Academy of Sciences of the USSR, Moscow, Russia, 1974).

Key words: amorphous magnetism; direct current sputtering; inelastic neutron scattering; magnetic structures; magnetism; neutron diffraction; rare earth alloys.

Neutron diffraction measurements have been taken on a 2-axis spectrometer as a function of temperature for sputtered $TbFe_2$. Difference patterns between the measurements as a given temperature and the measurement at $T > T_c$ show that the spin and atomic distribution is amorphous. The elastic and inelastic components of the scattering have also been measured separately by using a 3-axis spectrometer. These results show that for $T > T_c$, no coherent magnetic structure remains; the magnetic scattering is all inelastic. An anomalous low-angle tail present in the data is assumed to arise from magnetic inhomogeneities 20-30 Å in size. Application of a magnetic field of ~ 3 kOe at 77 K can cause these inhomogeneities to grow in size as well as to cause a small rearrangement of the spin distribution. Inelastic scattering experiments using time of flight analysis were made to obtain the differential cross section $S(Q,\omega)$ at room temperature and at $T > T_c$. At $T > T_c$ the spectrum is seen to be paramagnetic-like, as expected. At room temperature, comparison with the spectrum for a polycrystalline sample shows the amorphous sample to have a spectrum which is more spread out and shifted to lower energies. This result is in accord with recent calculations.

16556. Mahaffey, C. T., **Metrication problems in the construction codes and standards sector,** *Constr. Specifier*, pp. 25-28, 30-32, 34-37 (June 1976).

Key words: building regulations; dimensional coordination; metric conversion; planning and scheduling.

This report is a response to a request for an outline of the problems to be faced by the building standards development and building regulatory sectors of the American building industry. It includes a discussion of the SI metric units themselves, giving examples of the conventions regarding their use adopted in other countries to illustrate the nature of the decisions that must be made by the U.S. building industry. It discusses the relationship of dimensional coordination to the metric conversion effort, its impact on the U.S. building regulatory system and illustrates some of the decisions these sectors need to make. It also discusses some of the organizational problems required to involve all segments of the industry in this decision-making process, and for implementing these decisions in a coordinated way on a national scale.

16557. Robertson, A. F., **Estimating smoke production from rooms and furnishings,** *Proc. Int. du Batiment (CIB) Symp. on the Control of Smoke Movement in Building Fires, Garston, U.K., Nov. 4-5, 1975*, pp. 21-32 (Conseil International du Batiment (CIB), Garston, U.K., 1975).

Key words: building materials; fires; optical density; room furnishings; smoke production; smoke tests.

In the absence of specific analytical methods for measuring the hazards of fire gases, there is a trend towards the use of smoke production as a partial measure of this hazard. It is suggested that present smoke test methods may be best used to provide indications of the possible smoke production, i.e., product of specific optical density and fire exposed area, characteristic of fully involved furnishing and interior finish products. It is demonstrated that very large quantities of smoke will result from combustion of only small quantities of most combustibles. Because of this there is little opportunity for elimination of the smoke hazard during fires through establishment of any but the most drastic limitations on the smoke development characteristics of materials considered acceptable. Measures for limiting ignition and development of fires, together with containment and disposal of smoke when fires occur, appear the most promising methods for reducing hazards due to smoke.

16558. Bennett, H. S., Forman, R. A., **Photoacoustic methods for measuring surface and bulk absorption coefficients in highly transparent materials: Theory of a gas cell,** *Appl. Opt.* **15,** No. 10, 2405-2413 (Oct. 1976).

Key words: bulk absorption coefficients; Fourier amplitudes; gas pressure; heat transfer; phase shifts; photoacoustic; surface absorption coefficients; transparent materials.

Researchers seek improved ways to measure the surface absorption and the bulk absorption coefficients of highly transparent materials. Procedures are presented here by which one may determine separately the surface absorption and the bulk absorption coefficients. For the case in which a laser beam modulated at angular frequency ω passes through the weakly absorbing windows of a gas cell containing a nonabsorbing gas, the temperature profiles in the cell windows and the temperature and acoustic pressure or stress profiles in the gas have been calculated. These calculations indicate that for sufficiently low frequencies and high ambient gas pressure, enough heat transfers from the cell windows to the gas to produce a detectable acoustic pressure signal at angular frequency ω in the gas. These calculations also enable us to state the necessary measurements for determining the surface and bulk absorption coefficients. Measuring the acoustic stress amplitude at the fundamental and higher harmonic frequencies and measuring the phase shifts of the frequency components of the acoustic stress with respect to the modulated laser beam give sufficient data by which one can determine the surface and bulk absorption coefficients. Numerical examples for a representative laser glass and air (nitrogen) are given.

16559. Holt, H. K., **Laser intracavity absorption,** *Phys. Rev. A* **14,** No. 5, 1901-1902 (Nov. 1976).

Key words: absorption; intracavity; laser; low density.

The fractional absorption which can be obtained using a single-mode laser with an internal absorption cell is compared to the fractional absorption obtainable with the more conventional system of a laser with an external absorption cell.

16560. Snyder, L. E., Hollis, J. M., Lovas, F. J., Ulich, B. L., **Detection, identification, and observations of interstellar $H^{13}CO^+$,** *Astrophys. J.* **209,** No. 1, 67-74 (Oct. 1, 1976).

Key words: formyl ion; interstellar molecules; microwave emission; molecular structure; radio astronomy; rotational spectrum.

Observations of interstellar $H^{13}CO^+$ are presented, and results of the molecular-structure computations supporting this particular molecular identification are given. Preliminary values of integrated intensity ratios of $H^{12}CO^+/H^{13}CO^+$ have been found for the main HCO^+ clouds. Searches for $H^{12}C^{18}O^+$ were unsuccessful, and upper limits are given. U86.76, a new unidentified interstellar molecule which may be methylcyanoacetylene, was detected in Sgr B2.

16561. Boyne, H. S., **Laser power and energy measurements,** (Proc. Conf. Optical Design Problems in Laser Systems, San Diego, CA, Aug. 21-22, 1975), *SPIE* **69,** 90-94 (1975).

Key words: laser power and energy measurements; spatial response; temporal development.

Laser source and detector characterization necessary for laser systems design is reviewed. Power, energy and temporal development of sources are discussed. Also, the spatial response of detectors is addressed.

16562. Yaghjian, A. D., **A direct approach to the derivation of electric dyadic Green's functions,** *Proc. AP-S Int. Symp., University of Massachusetts, Amherst, MA, Oct. 11-15, 1976,* pp. 71-73 (Institute of Electrical and Electronics Engineers, New York, NY, Oct. 1976).

Key words: electromagnetic theory; Green's dyadic theory.

A straightforward yet rigorous approach that does not require distribution theory is used to derive a general electric dyadic Green's function which remains valid within the source region. Although the electric field expressed by the dyadic Green's function proves to be unique, the exact form of the dyadic itself depends upon the shape of its "principle volume." The dependence on principle volume is determined explicitly, and the different Green's dyadics derived by previous authors are shown to emerge merely through the appropriate choice for the principle volumes.

16563. Belsher, D. R., **Development of near-field electric energy density meter model EDM-2,** *HEW Publ. No. (NIOSH) 75-140,* 26 pages (U.S. Department of Health, Education, and Welfare, Cincinnati, OH, Mar. 1975).

Key words: electric energy density; energy density; near-field energy density.

The Occupational Safety and Health Administration (OSHA) Nonionizing Radiation Exposure Standard (29 CFE 1910.97, June 2, 1974) includes electromagnetic (E-M) radiation from 10 MHz to 100 GHz. However, no survey monitors presently are manufactured for making electric-field measurements of radiofrequency (rf) radiation from 10 to 300 MHz. Consequently, rf electric-field occupational exposure data cannot be collected until suitable monitoring instrumentation is available.

The relationship between the electric and magnetic fields is completely ambiguous for near-field surveys (within one wavelength of the source) of rf radiation sources. The electric and magnetic fields must be measured separately to obtain total occupational exposure. An electric-field survey monitor (EDM-2) was developed for the Physical Agents Branch, Division of Laboratories and Criteria Development, NIOSH, by the E-M Division, NBS to be used in assessing occupational exposure from industrial rf power sources.

The monitor employs a set of three orthogonal dipoles to obtain an essentially isotropic response. The dipoles are connected to the meter electronics by special high resistance conductors which have minimal interaction with the rf field. The meter displays electric energy density from 0.003 to 30 $\mu J/m^3$ which corresponds to plane-wave equivalent power density from 0.18 to 1800 mW/cm^2.

16564. Marshall, H. E., Ruegg, R. T., **Efficiency problems from user fees in municipal wastewater treatment,** *Water Resour. Bull.* **12,** No. 5, 903-917 (Oct. 1976).

Key words: cost sharing; economic efficiency; environment; equity; financing; grants; pollution abatement; user fees; wastewater; water pollution; water resources.

The Environmental Protection Agency administers a construction grant program to encourage abatement of wastewater pollution by sharing with municipalities the costs of wastewater treatment facilities. The enabling legislation (P.L. 92-500) specifies that EPA's cost share will be 75 percent of construction costs. It further requires municipalities to collect user fees from industrial users of the facilities to repay that part of the federal grant allocable to the treatment of industrial wastewater. The municipality must return half of the user fees collected to the U.S. Treasury; the municipality is allowed to retain the remaining half. Retention by municipalities of these user fees lowers their effective cost shares and results in the following consequences: (1) a bias for municipalities to select certain kinds of abatement techniques regardless of whether or not they are the least-cost techniques from the national perspective; (2) a bias for municipalities to select larger-than-optimal scales of abatement facilities; (3) a hidden federal subsidy to industry; and (4) grants that favor industrial communities. This article examines the legislative and regulatory requirements for user charges, derives the algebraic expressions for calculating the real federal, municipal, and industrial cost shares with user fees; computes municipal cost shares for selected values of the determinant factors; evaluates efficiency and other consequences of current user fee arrangements; and concludes that the efficiency distortions brought about by the impacts of user fees on cost sharing could be eliminated by requiring that all user fees collected from industry against the federal cost share be returned to the U.S. Treasury.

16565. Hubbard, C. R., Mighell, A. D., Staffa, J. A., Zervos, C., Konopelski, J. P., ***S*-carboxymethyl-L-cysteine sulfone,** *Acta Crystallogr.* **B32,** Part 9, 2723-2725 (Sept. 1976).

Key words: hydrogen bonding; single crystal; structure determination; *S*-carboxymethyl-L-cysteine sulfone; x-ray, zwitterion.

$C_5H_9SO_6N$, orthorhombic, $P2_12_12_1$; $a=9.205$ (4), $b=5.223$ (2), $c=15.891$ (7) Å; $Z=4$, $D_x=1.836$, $D_m=1.86$ (2) g cm^{-3} (flotation, 21 °C). The structure has been determined by direct methods and refined to an $R=0.045$ for 944 independent reflections. The title compound exists as a zwitterion. Two carboxyl groups in adjacent molecules [O...O, 2.504 (5) Å] are involved in a strong hydrogen bond. The hydrogen atom was found to be covalently bonded to the carboxyl group in the carboxymethyl moiety.

16566. Siedle, A. R., Todd, L. J., **Chemistry of metalloborane derivatives containing the $B_{10}H_{12}$ ligand,** *Inorg. Chem.* **15,** No. 11, 2838-2842 (1976).

Key words: boron hydrides; deuterium; iridium; maleonitriledithiolate; metalloboranes; nuclear magnetic resonance; oxidative addition; palladium.

Ligand displacement reactions of $(B_{10}H_{12})Pd(PPh_3)_2$ were used to prepare $[(B_{10}H_{12})Pd(CN)_2]^{2-}$, $\{(B_{10}H_{12})Pd[C_2S_2(CN)_2]\}^{2-}$, and $(B_{10}H_{12})Pd(1,10\text{-}C_{10}H_8N_2)$. The reaction of the latter phenanthroline complex with butyllithium produced $\{[(B_{10}H_{11})Pd]_2C_{10}H_8N_2\}^{2-}$. The reaction of $C_2S_2(CN)_2^{2-}$ with $[(B_{10}H_{12})Ir(CO)(PPh_3)_2]$ led to $\{(B_{10}H_{12})Ir(CO)[C_2S_2(CN)_2](PPh_3)_2\}^-$ and $\{(B_{10}H_{12})Ir[C_2S_2(CN)_2](PPh_3)_2\}^-$. The reaction of $[(C_2H_5)_4N][(B_{10}H_{12})Ir(CO)(PPh_3)_2]$ in 1,2-$C_2H_4Cl_2$ with D_2 led to a regiospecific H-D exchange at the B(5,10) positions and the isolation of a $(B_{10}D_2H_{10})$ analogue. In CH_3CN solvent, exchange also took place at the bridge hydrogen positions. A mechanism for this reaction was proposed. Exchange of the carbonyl group in the iridaborane with ^{13}CO was observed.

16567. Engen, G. F., Hoer, C. A., **Application of an "arbitrary" 6-port junction to power measurement problems,** *Proc. 1972 CPEM Conf. on Precision Electromagnetic Measurements, Boulder, CO, June 26-29, 1972,* pp. 100-101 (Institute of Electrical and Electronics Engineers, New York, NY, 1972).

Key words: directional coupler; power detectors; sidearm power detector.

A directional coupler with a sidearm power detector is a well known form of power monitor. With the addition of a second coupler and detector as shown in figure 1 the "reflected" as well as the "incident" power may be measured.

16568. Engen, G. F., Hoer, C. A., **Application of an arbitrary 6-port junction to power-measurement problems,** *IEEE Trans. Instrum. Meas.* **IM-21,** No. 4, 470-474 (Nov. 1972).

Key words: power meter; 6-port junction.

An analysis of an arbitrary 6-port junction, four ports of which are terminated by power meters, shows that the net power input (or output) at either of the remaining ports is a linear function of the four power meter indications. The validity of this result has been experimentally demonstrated at 10 GHz. This device promises to be a useful tool in a wide variety of power measurement and calibration problems.

16569. Hellwig, H., **Clocks and measurements of time and frequency,** *Proc. 1976 WESCON, Session 32*, pp. 1-4 (Institute of Electrical and Electronics Engineers, New York, NY, Sept. 1976).

Key words: clocks; frequency and time; measurement of time and frequency; time and frequency.

After a brief historical review, the present state-of-the-art in frequency and time standards of high performance will be reviewed.

Precision oscillators used in precision time and time interval applications include quartz crystal, rubidium gas cell, cesium beam, and hydrogen maser oscillators. A general characterization and comparisons of these devices is given including accuracy, stability, availability, cost, etc. Areas of special concern in practical applications are identified and a projection of future performance is given. An attempt is made to predict physical and performance characteristics of new designs potentially available in the near future such as novel crystal standards, superconducting cavity devices, etc.

Methods for measuring frequency stability are discussed.

The methods employed for measuring frequency are designed to include state-of-the-art oscillators: they are fairly simple, and commonly available components can be used in the measurement systems.

Physical interpretations of common noise processes are discussed and it is shown how frequency domain stability characteristics may be translated to time domain stability characteristics.

A brief survey of the capabilities of available and potentially available time and frequency transfer techniques is given, including portable clocks, satellite methods, and radio broadcasts.

16570. Kimbleton, S. R., Wood, H. M., **A load leveling support methodology for networking,** *Proc. Winter Simulation Conf., National Bureau of Standards, Gaithersburg, MD, Dec. 6-8, 1976*, pp. 247-253 (Association for Computing Machinery, New York, NY, 1976).

Key words: computer networking; load leveling; resource sharing; scheduling.

Networking provides an effective means for resource sharing; however, its utility for load leveling requires further demonstration. This paper examines obstacles to load leveling and concludes that the key issues relate to the possible loss of control over remotely processed jobs and data. Although an organizational framework necessary to provide appropriate control exists, the technological support mechanism necessary for control in the form of processing guarantees has not yet been developed. Such development requires an essentially real time control capability for determining both the feasibility of accepting remote jobs as well as the guarantees which can be stipulated when such jobs are offered for processing. The key component of this capability is shown to be a very fast analytically driven simulation technique which can be invoked at a given site each time a job is offered for processing. We note in passing that this control capability can be viewed as the "other" side of control limits. That is, while control limits are concerned with determining when system performance has strayed out of bounds, a control capability is concerned with dynamic control of system workload to keep system performance within bounds.

16571. Sawyer, D. E., Berning, D. W., **Mapping nonlinearities over the active regions of semiconductor devices,** *Proc. IEEE Letters* **64,** No. 11, 1635-1637 (Nov. 1976).

Key words: device nonlinearity measurements; hot spots, transistor; laser scanning; nondestructive tests; semiconductor devices; UHF transistor measurements.

A laser scanner employing a modulated low-power 0.633-μm He-Ne laser has been used in a nondamaging manner to locate portions of a silicon bipolar UHF transistor which electrically behave in a nonlinear manner at a signal frequency of 470 MHz. In effect, the method uses the device scanned as a frequency converter to produce an IF output for a display screen whenever the laser spot is incident on nonlinear regions.

16572. Hogan, P. B., Carlsten, J. L., Pichanick, F. M. J., Smith, S. J., Smith, W. W., **Spontaneous Raman processes in multiphoton excitation of sodium,** *Phys. Rev. Lett.* **37,** No. 15, 990-993 (Oct. 11, 1976).

Key words: atomic beams; multiphoton ionization; sodium; spontaneous Raman scattering in free atoms.

We have observed spontaneous Raman processes in a sodium atomic beam. When one sodium $3p\ ^2P$ fine-structure level is strongly excited by a dye laser, the other level is weakly populated by spontaneous Raman emission and the absorption of another laser photon. This effect is detected by further stepwise excitation plus photoionization. The observed magnitude agrees well with theory. This technique is much more sensitive than methods involving direct observation of the Raman emission.

16573. Corliss, E. L. R., Jones, F. E., **Method for estimating the audibility and effective loudness of sirens and speech in automobiles,** *J. Acoust. Soc. Am.* **60,** No. 5, 1126-1131 (Nov. 1976).

Key words: alarm signals; hearing; loudness functions; masking; sirens; speech recognition; traffic noise.

By using the parameters for the ear and the equations for a "communication theory" model of the behavior of the ear, a family of masking curves can be drawn up which one can apply to the conditions prevalent in automotive vehicles. From the behavior of the ear and its ability to resolve sounds in noise, estimates can be made of the conditions under which sirens and speech communications will be audible within motor vehicles moving in traffic, and some estimate can also be made as to their potential for attracting notice. These quantities can be read off by graphic techniques. Examples of their use are given.

16574. Mayo, S., Keller, R. A., Travis, J. C., Green, R. B., **Detection of sodium trace contamination in furnace atmospheres at 1000 °C,** *J. Appl. Phys.* **47,** No. 9, 4012-4016 (Sept. 1976).

Key words: dye laser use for resonance fluorescence; furnace atmosphere sodium contamination; furnace qualification; resonance fluorescence; sodium trace detection.

Free sodium atoms were detected by resonance fluorescence in an open contaminated quartz tube heated to 1000 °C. The

quartz tube and furnace were similar to those used in semiconductor device processing. Fluorescence was excited by a cw dye laser tuned to the sodium D_1 or D_2 transition and directed along the axis of the furnace. Fluorescence from the sodium D_2 line emitted in the axial direction was collected by a telescopic system and focused onto a photomultiplier tube. The estimated minimum detectable sodium density in the furnace is 5×10^5 atoms/cm^3. No free sodium was detectable on a processing tube that had not been intentionally contaminated.

16575. Engen, G. F., **Calibration of an arbitrary six-port junction for measurement of active and passive circuit parameters,** *IEEE Trans. Instrum. Meas.* **IM-22,** No. 4, 295-299 (Dec. 1973).

Key words: circuit parameters; networks; six-port.

It has been recently recognized that an arbitrary six-port junction, four arms of which are terminated in power meters, can be calibrated to measure the circuit parameters, v, i, z, a, b, Γ, etc., in addition to power. Because this scheme eliminates the need for frequency conversion, it provides a substantially simplified approach to the design of an automatic network analyzer. This paper outlines a calibration procedure for the six-port which is only slightly more complicated than that in use for existing automated measurement systems.

16576. Cotton, I. W., **New family of standards being developed,** *Computerworld*, pp. S/2-S/22 (Nov. 29, 1976).

Key words: computer networks; data communications; data networks; networks; packet switching; protocol; standards.

Recent developments in data network standards are briefly surveyed, including developments in call establishment, data link control, and packet switching.

16577. Sawyer, D. E., Berning, D. W., **Thermal mapping of transistors with a laser scanner,** *Proc. IEEE Letters* **64,** No. 11, 1634-1635 (Nov. 1976).

Key words: active devices; hot-spot behavior; laser scanning; nondestructive testing; silicon optical absorption coefficient; temperature mapping.

An active near-infrared laser scanner has been used to electronically map the temperature variations over the active regions of silicon interdigitated UHF transistors operating in the hot-spot regime. The principle makes use of the increase in electron-hole pair generation by the absorbed laser light with increasing temperature. The regions of enhanced photoresponse are displayed on a cathode-ray-tube display screen. Extensions to other devices and operating conditions, other than those which result in hot-spot operation, are suggested.

16578. Kuyatt, C. E., Mielczarek, S. R., Weiss, M. J., **Intensities of infrared transitions in N_2O and H_2CO by electron impact spectroscopy,** *J. Chem. Phys.* **65,** No. 9, 3481-3485 (Nov. 1, 1976).

Key words: H_2CO; inelastic electron scattering; infrared transitions; N_2O; relative intensities.

Measurements of relative intensities of infrared transitions in N_2O and H_2CO have been made using forward inelastic scattering of 100 eV electrons. Agreement with previous infrared and electron impact measurements is satisfactory, showing that infrared intensities can be obtained from electron scattering measurements without the need for pressure broadening or corrections for the spectrometer slitwidth.

16579. Browne, J. C., Lamaze, G. P., Schröder, I. G., **Ratio of neutron capture cross sections for ^{186}Os and ^{187}Os at 25-keV neutron energy,** *Phys. Rev. C* **14,** No. 3, 1287-1288 (Sept. 1976).

Key words: $E_n = 25$ keV; measured cross-section ratio; nuclear reactions; ^{186,187}Os(n,γ).

The ratio of the neutron capture cross sections for ^{186}Os and ^{187}Os was measured at the 25-keV iron-filtered neutron beam facility of a 10-MW reactor. A value of 0.41 ± 0.04 was obtained. Using this ratio, the age of the universe was determined via the Re-Os β-decay clock to be approximately 19×10^9 years.

16580. Baldwin, E. E., **Voltage-controlled attenuator has minimum phase shift,** *EDN/EEE*, p. 40 (Nov. 5, 1971).

Key words: FET; pi network; tank circuit.

A FET in a pi network makes a good attenuator at a specific radio frequency, but gives variable phase shift with changing attenuation. A tank circuit across source-drain leads solves the problem.

16581. Herbst, J. F., Watson, R. E., Lindgren, I., **Coulomb term U and $5f$ electron excitation energies for the metals actinium to berkelium,** *Phys. Rev. B* **14,** No. 8, 3265-3272 (Oct. 15, 1976).

Key words: actinium; excitation energy; U; $5f$ electron.

Relativistic Hartree-Fock-Wigner-Seitz band calculations have been performed for the actinide metals Ac through Bk in order to estimate the Coulomb term U and $5f$ electron excitation energies. Our calculations predict that the tetravalent state (four $6d$-$7s$ conduction electrons) is stable relative to the trivalent state for the lighter elements and that near uranium relative stabilization of the trivalent state occurs. We find that U increases from 2-3 eV for Th to 4-5 eV for the heavier elements considered. $5f$ level widths W are estimated and found to decrease from 2 to 1/2 eV; together with the results for U this points to progressive localization of the $5f$ states. The ratio U/W, which is most indicative of localization, takes on values intermediate between those for $3d$ and $4f$ electrons.

16582. Altschuler, H. M., **1. Commission I and the General Assembly. 2. The General Assembly as an open symposium,** *URSI Inf. Bull. No. 190*, 10-15 (Mar. 1974).

Key words: general assembly; open symposium.

The place of Commission 1 in the world of standards of physical measurements and whether or not the scientific programme at the General Assembly of Commission 1, as well as all other Commissions should be converted into an open Symposium are discussed in the paper.

16583. Kostkowski, H. J., **Uncertainties in the measurement of incoherent optical radiation,** *Proc. Symp. on Biological Effects and Measurement of Light Sources, Rockville, MD, Mar. 25-26, 1976*, pp. 107-114 (HEW, PHS, Food and Drug Administration, Bureau of Radiological Health, Rockville, MD, Oct. 1976).

Key words: accuracy; optical radiation measurement; radiometry; systematic errors; uncertainties.

Uncertainties for state-of-the-art measurements of incoherent optical radiation are about 1 percent. Uncertainties for measurements made under less than ideal conditions are considerably larger. The major reasons for these uncertainties and what is being done and can be done to reduce them are presented.

16584. Suenram, R. D., Johnson, D. R., Glasgow, L. C., Meakin, P. Z., **Laboratory microwave spectrum of $ClONO_2$,** *Geophys. Res. Lett.* **3,** No. 10, 611-614 (Oct. 1976).

Key words: atmospheric pollution; chlorine nitrate; dipole moment; microwave spectrum; ozone depletion; rotational constants; stratospheric chemistry.

The microwave spectrum of $ClONO_2$ has been analyzed in the laboratory under high resolution. Rotational constants are reported for the ground and lowest vibrational states of the ^{35}Cl and ^{37}Cl isotopic forms. From Stark effect measurements the electric dipole moment was found to have components along two principal axes, $\mu_a = 0.72 \pm 0.10$ Debye and $\mu_b = 0.28 \pm 0.04$ Debye. Difficulties encountered in handling gas phase samples of $ClONO_2$ are discussed in some detail.

16585. Siedle, A. R., **Organometallic derivatives of trithiones,** *J. Organomet. Chem.* **120,** 369-374 (Apr. 1976).

Key words: carbon-13 NMR; coordination compounds; metal carbonyl; thiocarbonyl; 1,3-dithiolane-2-thione; 1,3-dithiolene-2-thione.

Complexes of the type $LM(CO)_5$ (M = Cr, Mo) were prepared from (diolefin)$M(CO)_4$ and the 1,3-dithiolene-2-thione ligands, L = $C_3H_2S_3$, $C_3H_4S_3$ and $C_8H_6S_3$. Infrared, ^1H and ^{13}C NMR data indicated C_{4v} symmetry about the metal centre. The reaction of 3-methylbenzo-1,3-dithiolene-2-thione with $(C_5H_5)Co(C_8H_{12})$ produced a cobalt(III) methylbenzothiete derivative $(C_7H_6S_2)$-$Co(C_5H_5)$.

16586. Bowen, R. R., Reed, L. E., **Semiporous reinforcing fillers for composite resins: II. Heat treatments and etching characteristics,** *J. Dent. Res.* **55,** No. 5, 748-756 (Sept.-Oct. 1976).

Key words: composite resins; composites; dental materials; fillers; porous glass; radiopacity; reinforcements; wear.

Candidate experimental semiporous reinforcing filler particles were prepared by heat treatment of certain glass compositions, followed by crushing and etching. Optical microscopic techniques were aided by the use of certain dyes and staining procedures to manifest submicroscopic interconnected porosity in the surface of the particles. The goal of this endeavor was to develop semiporous glass reinforcing fillers for the improvement of dental composite materials.

16587. Bowen, R. L., Reed, L. E., **Semiporous reinforcing fillers for composite resins: I. Preparation of provisional glass formulations,** *J. Dent. Res.* **55,** No. 5, 738-747 (Sept.-Oct. 1976).

Key words: composite resins; composites; dental materials; fillers; porous glass; radiopacity; reinforcements; wear.

A conceptual means of obtaining improved bonding between filler particles and the polymeric binders of composites is presented. It involves preparing glass particles that separate into two interconnected vitreous phases when heated to an appropriate temperature, and then etching these to produce a porous surface layer. Candidate glass compositions were prepared and subjected to heat treatment in a gradient furnace. Compositions susceptible to phase separations were delineated.

16588. Phaneuf, R. A., Taylor, P. O., Dunn, G. H., **Absolute cross sections for emission of 284.7-nm (Hg II) and 479.7-nm (Hg III) radiation in electron-mercury-ion collisions,** *Phys. Rev. A* **14,** No. 6, 2021-2025 (Dec. 1976).

Key words: absolute cross sections; electron impact; mercury ions; 285-nm radiation; 480-nm radiation.

Crossed beams of electrons and Hg^+ ions have been used to measure absolute cross sections for emission of 284.7-nm radiation, resulting from excitation of a predominantly ground-state Hg^+ target to the $7s^2S_{1/2}$ state. Values range from 3×10^{-17} cm^2 near threshold, where the cross section is strongly peaked, to 1.3×10^{-18} cm^2 at 280 eV. Also reported are some measurements of emission of 479.7-nm (Hg III) radiation, resulting from electron impact on both Hg^+ and Hg^{++} targets. Cross sections range from approximately 5×10^{-19} to 5×10^{-20} cm^2, and in the case of electron-Hg^{++} collisions, are more than an order of magnitude smaller than predicted by an available semiclassical binary-encounter calculation.

16589. Tsai, D. H., MacDonald, R. A., **Molecular-dynamical study of second sound in a solid excited by a strong heat pulse,** *Phys. Rev. B* **14,** No. 10, 4714-4723 (Nov. 15, 1976).

Key words: anharmonic crystal; computer simulation; energy transport; heat pulse; molecular dynamics; second sound; stress pulse; temperature wave; thermal diffusivity; thermal equilibrium; thermal relaxation.

We use the method of molecular dynamics to study the problem of heat transfer in a perfect semi-infinite bcc lattice when a strong heat pulse is applied at the boundary. We find that the disturbance propagates into the lattice as a combination of first sound and second sound superimposed on a diffusive background. The second-sound wave is a composite of several waves. We are able to show that the longitudinal and transverse sound waves, traveling with velocity C_l and C_s, respectively, are generated by the disturbance when the boundary of the lattice is rapidly heated or cooled. These stress-induced pulses are not in thermal equilibrium but they generate their own temperature waves, which travel with velocities $C_l/\sqrt{3}$ and $C_s/\sqrt{3}$, and which contribute to the observed second-sound wave. The disturbance in kinetic energy produced during the period of steady heating in the pulse propagates as a temperature wave with the theoretically expected second-sound velocity, $C_{av}/\sqrt{3}$. We relate these results to theoretical and experimental work on second sound excited by a weak pulse and also to our earlier calculations where the temperature wave is excited by shock compression.

16590. Stockbauer, R., Inghram, M. G., **The fragmentation of propane and deuteropropane molecular ions,** *J. Chem. Phys.* **65,** No. 10, 4081-4092 (Nov. 15, 1976).

Key words: coincidence; mass spectrometry; photoionization; propane; propane-d_2; propane-d_6; propane-d_8; threshold photoelectron spectroscopy.

Fragmentation of molecular ions as a function of internal energy has been studied for the propane molecules, C_3H_8, $CH_3CD_2CH_3$, $CD_3CH_2CD_3$, and C_3D_8 using threshold photoelectron-photoion coincidence mass spectrometry. Within the energy range covered (0-6 eV internal energy) the experimental fragmentation curves are compared with those calculated using the quasiequilibrium theory. The general features of the experimental curves are reproduced by the calculations but significant deviations from exact calculations are apparent. The experimental curves for the d_2 and d_6 propanes show that hydrogen scrambling processes occur and are of sufficient importance that they must be included in future calculations.

16591. Truhlar, D. G., Wyatt, R. E., **History of H_3 kinetics,** *Ann. Rev. Phys. Chem.* **27,** 1-43 (1976).

Key words: chemical reactions; collision theory; cross sections; dissociation; hot atoms; isotope effects; kinetics; molecular beams; quantum mechanics; rate coefficients; recombinations; scattering theory.

The gas-phase reaction of H with H_2 has been of fundamental interest since London (1929) pointed out that it can be understood in terms of a potential energy surface calculated from quantum mechanics. It has also been the only gas-phase bimolecular reaction for which curvature of the Arrhenius plot could be observed at low temperature (Marshall and Purnell 1968). Thus it served as a model for theories of tunneling. Because every atom involved can be substituted by D or T, it has been an important prototype system for isotope effect considerations. Because good photochemical and nuclear recoil sources of

hot (i.e., fast) H, D, or T atoms are available, it has also been studied under nonthermal high-energy conditions (Rowland 1970). In addition it has been extensively studied by classical and quantum mechanical collision theory.

16592. Bowman, R. R., **Quantifying hazardous electromagnetic microwave fields: Practical considerations,** *Proc. Biological Effects and Health Implications of Microwave Radiation, Richmond, VA, Sept. 17-19, 1969, BRH/DBE 70-2,* 204-209 (U.S. Dept. of Health, Education, and Welfare, Rockville, MD, June 1970).

Key words: electromagnetic microwave fields.

This paper is concerned mainly with the problem of making easy, reasonably accurate survey measurements of hazardous EM fields. For general survey use, instruments should be rugged, easy-to-use, and should be capable of fast response as well as having long-term averaging capabilities. These, and other considerations to be discussed, place restrictions on practical instrument designs for general survey use.

16593. Duff, J. W., Truhlar, D. G., **Classical S matrix: Application to classically forbidden vibrational excitation for He + HBr and H + Br_2,** *Chem. Phys.* **17,** 249-254 (Oct. 1976).

Key words: classical scattering matrix theory; collision theory; scattering theory; trajectories.

The integral expressions of classical S matrix theory are tested against quantum mechanical results and classical path-forced quantum oscillator results for vibrational transition probabilities in collinear collisions of atoms with harmonic and Morse vibrators for the H + Br_2 and He + HBr mass combinations. The interaction potential is assumed to be a repulsive exponential function. The energy range studied (in units of $\hbar\omega_e$) is 2-10 for H + Br_2 and 2-6 for He + HBr. The integral expressions are found to be accurate within a factor of two for almost all transition probabilities greater than 7×10^{-3} but to be very inaccurate for very small transition probabilities. Quasiclassical trajectory histogram methods are found to be accurate within a factor of two only for transition probabilities greater than 0.15. Neither the integral expressions of classical S matrix theory nor the quasiclassical trajectory histogram method are found to be as generally accurate as the classical path-forced quantum oscillator results.

16594. Green, R. B., Travis, J. C., Keller, R. A., **Resonance flame atomic fluorescence spectrometry with continuous wave dye laser excitation,** *Anal. Chem.* **48,** No. 13, 1954-1959 (Nov. 1976).

Key words: atomic flame fluorescence; barium fluorescence; cw dye laser; sodium fluorescence.

The potential contribution of continuous wave (CW) dye laser excitation of resonance atomic fluorescence for analytical flame spectrometry was evaluated. Noise sources which were related to fluctuations in the flame and in the laser scatter were responsible for the observed detection limits which were an improvement over those achieved with previously used excitation sources for flame atomic fluorescence and comparable to results for flame emission spectrometry. Based on experimental data, it was estimated that continuous wave excitation powers of 1-10 watts would be sufficient to bring the signal-to-noise ratio into a constant range. With the exception of nonresonant detection and saturation contributions to reduced quenching, higher laser powers common to pulsed sources are of no advantage and, in fact, are detrimental to sensitivity. Other aspects of CW dye laser excitation are presented and discussed.

16595. Haus, J. W., Meijer, P. H. E., **Static aspects of a model for metastable fluid states,** *Physica Letter to the Editor* **80A,** No. 3, 313-317 (1975).

Key words: limit of stability; mean field theory; metastability; perturbation scheme; reference system; structure factor.

A mean field-theory originally presented by Brout is used to obtain the limit of (meta-) stability for a Lennard-Jones system. Certain aspects of the theory are discussed in relation to recent results for liquid-solid phase transitions.

16596. Julienne, P. S., **$^3\Sigma_u^-$-$^3\Sigma_u^+$ coupling in the O_2 $B^3\Sigma_u^-$ predissociation,** *J. Mol. Spectrosc.* **63,** 60-79 (1976).

Key words: molecular oxygen; predissociation; Schumann-Runge bands; spin-orbit mixing.

The role of $B^3\Sigma_u^-$-$2^3\Sigma_u^+$ spin-orbit mixing in the O_2 Schumann-Runge predissociation is investigated. The $2^3\Sigma_u^+$ state is found to cross the $B^3\Sigma_u^-$ state near 2.0 Å with an interaction matrix element of approximately 55 cm^{-1}. This state contributes to the widths of the B $v \geq 6$ levels, but introduces only small level shift perturbations. When the partial widths due to the $^3\Sigma_u^-$-$^3\Sigma_u^+$ interaction are added to the previously calculated widths due to the $^5\Pi_u$, $^3\Pi_u$, and $^1\Pi_u$ states, reasonable agreement is obtained with experimental measurements on $O^{16}O^{16}$ and $O^{18}O^{18}$. The possibility of non-Lorentzian line profiles and the dependence of the width on rotational quantum number is investigated. The approximation of the spin-orbit matrix element by its value at the crossing point is shown to be a good approximation for calculating the second difference perturbations.

16597. Swartzendruber, L. J., Bennett, L. H., Watson, R. E., **Mössbauer studies of hydrided TiFe,** *J. Phys. F: Metal Phys. Letter to the Editor* **6,** No. 12, L331-L334 (1976).

Key words: charge flow; isomer; Mössbauer; phase diagram; $TiFeH_x$ alloys; volume effects.

The metallurgical and electronic structure of $TiFeH_x$ alloys are probed by ^{57}Fe Mössbauer effect studies. Our results are qualitatively consistent with and support Reilly and Wiswall's conclusions on the phase diagram. Volume effects and charge flow are both important in the isomer shift.

16598. Lias, S. G., Ausloos, P., **Reactions of CCl_2H^+ and CF_2H^+ with organic and inorganic compounds: proton affinities and heats of formation of CCl_2 and CF_2,** *Int. J. Mass Spectrom. Ion Phys.* **22,** 135-145 (1976).

Key words: CCl_2, CF_2; CCl_2H^+, CF_2H^+; displacement reactions; four-center reactions; ion molecule reactions; proton affinity; proton transfer; rate coefficients.

The reactions of CCl_2H^+ (or CCl_2D^+) and CF_2H^+ with a number of aldehydes, ketones, esters, organic acids, alcohols, amines and inorganic compounds have been observed. Since the proton affinities of most of these compounds are known, it was possible on the basis of the observation or nonobservation of proton transfer reactions to obtain proton affinities for CF_2 and CCl_2 of 7.74 ± 0.04 eV (178.6 ± 1 kcal $mole^{-1}$) and 8.69 ± 0.06 eV (200.4 ± 1.5 kcal $mole^{-1}$), respectively. In addition to proton transfer, CCl_2H^+ and CF_2H^+ undergo reactions with carbonyl-containing compounds entirely analogous to those which have been observed for other halomethyl ions. That is, with aldehyde and ketone reactants, four-center reactions resulting in the formation of a mono-halogenated carbonium ion are the major competing processes, and with esters and acids elimination reactions and four-center reactions resulting from attack by the ion at the acyl oxygen are important. These ions also displace carbonium ions from alcohols, and abstract hydride ions from esters and amines. Charge transfer is an important competing channel in reactions with amines.

16599. Richmond, J. C., **Image quality of photoelectronic imaging systems and its evaluation,** (Proc. 6th Symp. on Photo-Elec-

tronic Image Devices, London, England, Sept. 9-13, 1974), Paper in *Advances in Electronics and Electron Physics*, L. Marton, Ed., **40B,** 519-538 (Academic Press, New York, NY, 1976).

Key words: blooming; contrast transfer function; distortion; flare; image quality; light induced background; limiting resolution; night vision devices; optical transfer function; resolution charts; veiling glare.

Image quality is probably the single most important parameter in determining the usefulness of any optical device. For night vision systems in particular, image quality is of paramount importance. Subjective evaluation of image quality is surprisingly good. An observer will have no difficulty in ranking a number of photographs in order of overall image quality. The general agreement between different observers on the order of ranking of the same series of photographs will also be good. However, objective evaluation of image quality in quantitative terms is not easy. Many variables contribute to image quality, not all of which have been identified, or can be quantitatively evaluated. This paper is primarily a literature survey of criteria and techniques that have been used to evaluate the quality of imaging systems, with some discussion of their application to image intensifier night vision devices.

16600. Wiederhorn, S. M., Roberts, D. E., **A technique to investigate high temperature erosion of refractories,** *Bull. Am. Ceram. Soc.* **55,** No. 2, 185-189 (1976).

Key words: castable refractories; coal gasification; deformation; erosion; fracture; wear.

A description is given of equipment used to study erosion of refractories under controlled environments at temperatures as high as 1500 °C. Erosive wear of a high alumina castable refractory currently used in coal gasification pilot plants is investigated. Erosion occurs preferentially in the cement matrix of the refractory. At 25 °C erosion occurs by brittle fracture of the matrix, while at 1000 °C, erosion occurs by fracture and shear deformation of the matrix phase. Data are discussed with reference to current theories of erosion.

16601. Haus, J. W., Meijer, P. H. E., **Dynamics of metastable fluid states in the liquid-solid transition,** *Phys. Rev. A* **14,** No. 6, 2285-2294 (Dec. 1976).

Key words: hydrodynamic regime; ideal gas memory function; limit of stability; metastable fluid states; nonhydrodynamic regime; relaxation time; transport coefficients; Zwanzig-Mori formalism.

A fluctuation theory for the dynamics of metastable fluid states is presented which relies on a limiting form for the static structure factor $S(k)$ previously presented by the authors. The transport coefficients are found to show a divergence in the hydrodynamic regime. In the nonhydrodynamic regime a model is presented which uses an approximate single-particle memory function and a diffusive mode is found; this is compared with fluctuation theory results of other workers. A recent computer experiment has shown numerical agreement with the static model.

16602. Simmons, J. A., Clough, R. B., **Theoretical aspects of acoustic emission spectral measurements,** *Proc. Eighth World Conf. on Nondestructive Testing, Cannes, France, Sept. 6-10, 1976*, pp. 1-8 (Imprimplans, Paris, France, 1976).

Key words: acoustic emission; dislocations; nondestructive evaluation; spectral analysis.

Frequency spectrum analysis of acoustic emission signals shows great promise as a nondestructive test method. It has potential for discriminating between harmful moving defects and system noise as well as for revealing more of defect characteristics than are currently revealed with threshold counting techniques. However, such an analysis required a systematic examination of the entire emission process.

In this paper, we describe progress in developing the theory of acoustic emission. More specifically, we examine acoustic emission from planar, straight line dislocation segments moving in bursts. For simplicity, we will for the present treat the ideal case of an infinite isotropic body. This case should, however, provide an illustration of the general nature of the acoustic emission spectrum and how it is produced.

16603. Hall, J. L., Bordé, C. J., Uehara, K., **Direct optical resolution of the recoil effect using saturated absorption spectroscopy,** *Phys. Rev. Lett.* **37,** No. 20, 1339-1342 (Nov. 15, 1976).

Key words: CH_4 hyperfine structure; high resolution spectroscopy; laser spectroscopy; line shape; optical frequency standards; recoil effect; relativity.

The recoil-induced spectral doubling of the CH_4 saturated absorption peaks at 3.39 μm has been clearly resolved. A working resolving power of 8×10^{10} (1 kHz half width at half-maximum), achieved with aberration-compensated parabolic optics of 32 cm diam, was available to study the height ratio and splitting of the recoil peaks. The resolved Doppler-generated level crossings are not recoil doubled and give improved hfs information. We derive new, exact equations relating the atomic natural frequency to laboratory resonance frequencies.

16604. Green, R. B., Keller, R. A., Luther, G. G., Schenck, P. K., Travis, J. C., **Galvanic detection of optical absorptions in a gas discharge,** *Appl. Phys. Lett.* **29,** No. 11, 727-729 (Dec. 1, 1976).

Key words: discharge; discharge tubes; hollow cathode; spectroscopy; trace detection; tunable lasers.

An electrical signal, resulting from discrete optical absorptions, has been observed for a variety of elements, including several for which such an effect had not been previously reported. In the present case, the effect is observed as a change in the voltage across a gas discharge tube produced by irradiation with a laser tuned to the wavelength of a transition of a species in the discharge. This signal may be used—without optical detection apparatus—for spectroscopic investigations or analytical determinations of materials in the discharge. Signals were obtained for transitions of lithium, sodium, calcium, barium, uranium, neon, and helium, in commercial hollow cathode lamps, and neon and helium in conventional discharge tubes.

16605. Latour, J., Spiegel, E. A., Toomre, J., Zahn, J. P., **Stellar convection theory. I. The anelastic modal equations,** *Astrophys. J.* **207,** No. 1, 233-243 (July 1, 1976).

Key words: convection theory; convection zones; stellar structures.

We present here a system of equations for stellar convection theory. These equations follow from the full equations of compressible fluid dynamics with the introduction of two important approximations. The first of these is the anelastic approximation, commonly used in meteorology. Its aim is to filter out acoustic waves so that the task of numerical solution will not be complicated by the need to resolve very rapid time variations. The anelastic approximation is justified when the frequencies and Mach numbers of the convection are not too high. Its basic effect is to suppress terms which are nonlinear in the horizontal fluctuations of the thermodynamic variables, but it allows large vertical variation in the mean density and preserves the dynamical nonlinearities. The second approximation is a drastic simplifica-

tion of the horizontal structure of the convection. It consists of expanding the fluctuating quantities in a set of modes which are periodic in the horizontal coordinates, and then truncating after a few terms.

The resulting system of nonlinear partial differential equations (in vertical coordinate and time) is still formidable, and its numerical resolution has so far been achieved only for relatively simple cases of stellar convection, to be presented in subsequent papers. These anelastic modal equations can also be used to treat more complicated problems such as semiconvection and the coupling of convection to radial pulsation or rotation.

16606. Toomre, J., Zahn, J. P., Latour, J., Spiegel, E. A., **Stellar convection theory. II. Single-mode study of the second convection zone in an A-type star,** *Astrophys. J.* **207,** No. 2, 545-563 (July 15, 1976).

Key words: A-type stars; convection theory; convection zones; metallic-line stars; stellar structure.

The anelastic modal equations presented in Paper I are considered in their simplest version: only one mode is retained in the representation of the fluctuating dynamic and thermodynamic variables of convection theory. These single-mode equations are used to examine the structure of the second convection zone of an A-type star. Two- and three-dimensional numerical solutions are obtained for a range of parameters in the theory, and a simple analysis is provided for their interpretation.

The principal results are for three-dimensional motions, since these are most likely to be relevant to stellar convection. Such motions produce a convective heat flux several orders of magnitude greater than predicted by standard mixing-length theory for the same situation; we find that convection carries up to 6 percent of the total flux. The most significant astrophysical implication of our results is that they suggest strong overshooting into the adjacent radiative zones. We anticipate that mixing will extend to the overlying hydrogen convection zone. This would rule out some interpretations of metallic-line stars which invoke diffusive element separation between the two convection zones.

16607. Truhlar, D. G., **Quasiclassical predictions of final vibrational state distributions in reactive and nonreactive collisions,** *Int. J. Quant. Chem. Symp.* **10,** 239-250 (1976).

Key words: chemical reactions; classical probability matrix theory; classical scattering matrix theory; collision theory; energy transfer in collisions; hydrogen molecules; information theory; scattering theory; trajectories; vibrational energy.

The validity of quasiclassical and semiclassical trajectory methods for predicting state-to-state vibrational transition probabilities in collisions of atoms with diatomic molecules is discussed with special emphasis on tests against accurate quantum calculations for $He + H_2$, $H + Cl_2$, and $I + H_2$ collisions.

16608. Norcross, D. W., Seaton, M. J., **Energy levels for Be I calculated using a model potential and cores approximation,** *J. Phys. B* **9,** No. 17, 2983-3000 (Dec. 1976).

Key words: Be energy levels; model potential theory.

A two electron model Hamiltonian, used for Be I, includes a core polarization potential $V_{POL}(1,2)$ which has asymptotic form $V_{POL} \sim -\alpha\{(\hat{r}_1/r_1^2)+(\hat{r}_2/r_2^2)\}^2$ where α is the polarizability of Be III $1s^2$. Solutions are obtained using a frozen cores method. Two approximations are considered: (a) uses an expansion with core states Be II 2s and 2p; (b) includes in addition a 3d core orbital with a parameter determined variationally. For the series ^1S, ^3S, $^1P^\circ$, $^3P^\circ$, ^1D, ^3D, $^1F^\circ$ and $^3F^\circ$ results are obtained for all bound states ($\epsilon < 0$) with $n_s \leq 10$, for $n = \infty$ ($\epsilon = 0$), and for the first resonances states in the region $\epsilon > 0$. For the series ^1P, ^3P, $^1D^\circ$, $^3D^\circ$ converging to Be II 2p, results are obtained for $n \leq 10$ and for $n = \infty$. The calculated ionization energies are more accurate than those obtained in previous theoretical work.

16609. Avrett, E. H., Vernazza, J. E., Linsky, J. L., **Excitation and ionization of helium in the solar atmosphere,** *Astrophys. J.* **207,** No. 3, L199-L204 (Aug. 1, 1976).

Key words: helium; radiative transfer; solar chromosphere; spectral line formation.

We investigate the excitation and ionization of He I and He II for the case of a realistic solar model. The calculations are based on a simplified numerical treatment of the He I and He II continua and the He II λ304 line. We discuss the extent to which various proposed mechanisms can account for the observed line and continuum intensities.

16610. Hall, J. L., Bordé, C. J., **Shift and broadening of saturated absorption resonances due to curvature of the laser wave fronts,** *Appl. Phys. Lett.* **29,** No. 12, 788-790 (Dec. 15, 1976).

Key words: lineshape theory; optical frequency standards; saturated absorption spectroscopy.

Using frequency offset-locked spectroscopy of methane at 3.39 μm we show that the saturated absorption peaks can be significantly blue or red shifted if the wave fronts of the laser beam are spherical in the gas cell. Good agreement with theoretical prediction is found. We discuss suitable conditions to avoid this geometry-induced shift in optical frequency standards.

16611. Kahn, L. R., Baybutt, P., Truhlar, D. G., *Ab initio* **effective core potentials: Reduction of all-electron molecular structure calculations to calculations involving only valence electrons,** *J. Chem. Phys.* **65,** No. 10, 3826-3853 (Nov. 15, 1976).

Key words: basis functions; configuration mixing; dipole moments; electronic structure of molecules; Hartree-Fock; integrals, evaluation of; molecular structure; orbitals; potential energy curves; pseudopotentials; self-consistent field; valence electrons.

A formalism is developed for obtaining *ab initio* effective core potentials from numerical Hartree-Fock wavefunctions and such potentials are presented for C, N, O, F, Cl, Fe, Br, and I. The effective core potentials enable one to eliminate the core electrons and the associated orthogonality constraints from electronic structure calculations on atoms and molecules. The effective core potentials are angular momentum dependent, basis set independent, and stable against variational collapse of their eigenfunctions to core functions. They are derived from neutral atom wavefunctions using a pseudo-orbital transformation which is motivated by considerations of the expected accuracy of their use and of basis set economy in molecular calculations. Then the accuracy is demonstrated by multiconfiguration Hartree-Fock calculations of potential energy curves for HF, HCl, HBr, HI, F_2, Cl_2, Br_2, and I_2 and one-electron properties for HF and HBr. The differences between valence-electron calculations employing the present effective core potentials and all-electron calculations are smaller than differences due to basis set choices, even though the basis sets are extended ones. Thus the effective core potentials are quite successful. In addition larger configuration mixing calculations are performed for HBr and Br_2 (1637 and 3396 configurations, respectively) and again the effective core potentials are judged to perform well.

16612. Richards, J. L., Johnson, P. M., **The visible emissions of molecular oxygen in rare gas solids,** *J. Chem. Phys.* **65,** No. 10, 3948-3951 (Nov. 15, 1976).

Key words: emission spectra; intersystem crossing; molecular oxygen in rare gas solids; O_2 excited states.

The vacuum ultraviolet-excited emission spectra of molecular oxygen in low temperature rare gas solids have been recorded and analyzed. The observed transitions have been reassigned using isotopic substitution and are found to be $C^3\Delta_u \rightarrow X^3\Sigma_g^-$ in argon and krypton and $c^1\Sigma_u^- \rightarrow a^1\Delta_g$ in xenon. These transitions have not been observed in the gas phase and the transition origins established here confirm previous tentative assignments of vibrational numberings of the upper states by Herzberg and Degan, respectively. The emission in xenon is very unusual for a solid phase spectrum in that emission occurs from several excited vibrational levels, which are apparently being populated directly by intersystem crossing. It is also unusual in that the lower state of the emission is not the ground state. No significant chemical interaction between the molecule and the rare gas is seen for any of the observed states.

16613. Mihalas, D., Kunasz, P. B., Hummer, D. G., **Solution of the comoving-frame equation of transfer in spherically symmetric flows. IV. Frequency-dependent source functions for scattering by atoms and electrons,** *Astrophys. J.* **210,** No. 2, 419-433 (Dec. 1, 1976).

Key words: early-type stars; electron scattering; spectral-line formation; stellar atmospheres.

A numerical method is presented of solving the radiative transfer equation in the comoving frame of a spherically symmetric expanding atmosphere in which both the line and the electron-scattering source function can depend on frequency (i.e., when there is partial frequency redistribution in the scattering process). This method is used to assess the adequacy of various assumptions regarding frequency redistribution in the comoving frame and to discuss the effects of electron scattering more accurately than previously possible. The methods developed here can be used in realistic model atmospheres to account for the (major) effects of electron scattering upon emergent flux profiles.

16614. Langhoff, P. W., Hernandez, A. J., **On the Brueckner and Goldstone forms of the linked-cluster theorem,** *Int. J. Quant. Chem. Symp.* **10,** 337-352 (1976).

Key words: diagrammatic perturbation theory; linked-cluster theorem; many-body theory.

Connections between the Brueckner and Goldstone forms of the linked-cluster theorem are clarified in an elementary fashion employing a finite many-body system of electrons interacting via two-body forces as an illustrative example. It is shown that the order-by-order cancellations of Brueckner unlinked terms in the many-body wave function and energy occur in the Goldstone development upon the additions of the different time orderings of Feynman-Goldstone diagrams having disconnected vacuum parts. The factoring of the vacuum amplitude from the wave function, upon which customary presentations of the theorem focus attention, is shown to be irrelevant to the cancellations of Brueckner unlinked terms, and has to do, rather, with the presence of secular and normalization terms in the time-dependent perturbation functions for an adiabatically-switched static perturbation. Similarly, the equivalence of the vacuum amplitude with the exponential of all connected vacuum diagrams, originally demonstrated by Feynman in the case of hole theory, is shown to be irrelevant to the cancellations of Brueckner unlinked terms in the energy, which occur in the Goldstone development upon the summations over all time orderings of disconnected vacuum diagrams. The distinction between Brueckner unlinked terms on the one hand, and secular and normalization terms on the other, is confused in customary presentations of the linked-cluster theorem by the use of exponential switching, following Gell-Mann and Low, and is clarified in the present development by considering the Friedrichs limit of ideal adiabatic switching.

16615. Zamir, E., Szöke, A., Osgood, R., **Fluorescence and dissociative energy transfer in high pressure Ar-HCN mixtures excited by relativistic electrons,** *J. Chem. Phys.* **65,** No. 11, 4885-4894 (Dec. 1, 1976).

Key words: energy transfer, electronic; fluorescence; molecular dissociation; relativistic electrons, excitation.

Studies of the radiation from Ar-HCN and Ar-H_2O mixtures, excited by relativistic electrons from a Febetron 706 electron gun, are presented. The energy deposited by the electrons channels rapidly into the Ar* and Ar_2* states; then by dissociative collisions with HCN it is transferred partly into the CN(B) state and partly into a reservoir state [most probably the CN(A) state] with near unit efficiency. Fluorescence emission from the electronic states $A(^2\Pi_i)$ and $B(^2\Sigma^+)$ of the CN radical, as well as the emission from the Ar_2* excimer state, were measured for an Ar pressure range of 750-9000 torr [15-180 psi(absolute)], and an HCN pressure range of 0.2-13 torr. The quenching rates of Ar* metastable and the Ar_2* excimer states, by collision with HCN molecules, were measured to be 6×10^{-10} and 1×10^{-9} cm^3 sec^{-1}, respectively. Our results suggest that population inversion can be achieved by collisional dissociation of simple molecules with excited rare gas atoms and excimers. Indeed the peak CN(B) population density was found to be 1.5×10^{15} cm^{-3}, which corresponds to an optical gain for the B-X transition of 0.4 cm^{-1} if the ground state is empty. A computer kinetic model is presented that explains the time dependence and intensity of the CN(B) emission. In Ar-H_2O mixtures the reaction rate for quenching of Ar_2* excimer by H_2O molecules is extremely high; however, the yield into the OH($A^2\Sigma^+$) is only 3 percent.

16616. Maxfield, B. W., Linzer, M., McConnaughey, W. B., Hulbert, J. K., **Design of permanent magnet electromagnetic acoustic-wave transducers (EMATs),** *Proc. 1976 IEEE Ultrasonics Symp., Annapolis, MD, Sept. 29-Oct. 1, 1976,* 4 pages (The Institute of Electrical and Electronics Engineers, Inc., New York, NY, 1976).

Key words: electromagnetic transducer; EMAT; transducer; ultrasonics.

Electromagnetic acoustic-wave transducers (EMATs) provide a means of generating and detecting shear and compressional acoustic waves of known amplitude in conductors by electromagnetic instead of mechanical coupling to the material under study. An EMAT consists of a coil to generate eddy currents in the conductor and a magnetic field to provide coupling between the eddy currents and the metal lattice. Most work to date has been on EMATs utilizing either large permanent magnets or electromagnets. Here we describe a simple but very practical model for a rare-earth cobalt permanent magnet EMAT. This model is analyzed in detail and compared with measurements of the performance of a compact (250 gram) EMAT.

16617. Wiederhorn, S. M., Fuller, E. R., Jr., Mandel, J., Evans, A. G., **An error analysis of failure prediction techniques derived from fracture mechanics,** *J. Am. Ceram. Soc.* **59,** No. 9-10, 403-411 (Sept.-Oct. 1976).

Key words: crack propagation; error analysis; failure prediction; failure prevention; fracture; statistics; strength.

Three principal methods of failure prediction for brittle materials are analyzed statistically. Each method depends on fracture mechanics for its predictive value; hence the variance of the failure time depends on the scatter in the fracture mechanics data and the scatter in the estimate of the initial size of the strength-limiting crack. The variance is used to calculate confidence limits

for the prediction of failure for glass and SiC. Procedures for the collection and analysis of data are discussed and the implications of the analysis for lifetime prediction are evaluated.

16618. Brandt, M. A., Truhlar, D. G., Van-Catledge, F. A., **Electron scattering by nitrogen molecules: Theory and application to elastic scattering and rotational excitation at 30-75 eV,** *J. Chem. Phys.* **64,** No. 12, 4957-4967 (1976).

Key words: close coupling calculations; cross sections; differential cross sections; elastic scattering; electron scattering; momentum transfer; nitrogen molecules; rotational excitation; scattering theory.

An effective potential model applicable to electron scattering by small or large molecules, including rotational and vibrational motions, is developed for electron scattering by N_2. The INDO-/1*s* method is used to calculate the static potential at a large number of distances and a simple model is used for the polarization potential. The rotational and vibrational matrix elements of these potentials are accurately calculated and the scattering is treated by a truncated close-coupling expansion. With no adjustable parameters, calculated electronically and vibrationally elastic scattering cross sections are in reasonable agreement with experiment for angles 40°-50° and less at energies 30-75 eV. The rotational excitation cross sections have never been measured for N_2 but are predicted to be large (as large as half the pure elastic cross sections when integrated over scattering angles and larger than the pure elastic differential cross sections at a range of large scattering angles at each energy).

16619. Kostkowski, H. J., **Current status and future plans for NBS radiometric source standards,** *Proc. AIAA/NASA/ASTM/IES Space Simulation Conf. Silver Spring, MD, Nov. 3-5, 1975,* Paper No. 66, pp. 799-805 (National Aeronautics and Space Administration, Washington, DC, 1976).

Key words: blackbodies; lamp standards; radiometry; remote sensing; solar monitoring; source standards.

The accuracy and long-term stability of currently available NBS radiometric source standards will be described. Current research efforts and expected results in this area will be outlined.

16620. Buehler, M. G., Sawyer, D. E., **Microelectronic test patterns for use in procuring reliable, custom integrated circuit chips,** (Proc. Government Microcircuit Applications Conf., Orlando, FL, Nov. 9-11, 1976), Paper in *Government Microcircuit Applications Conference Digest,* **VI,** 62-65 (Nov. 1976).

Key words: circuit procurement; component screening; custom circuits; LSI; microelectronics; parameter control; process uniformity; random faults; reliability; test patterns; TTL; vendor qualification.

The current procurement methods for obtaining custom integrated circuits for high-reliability applications are expensive, less than fully effective, and cause long delays in delivery.

An approach being developed at the National Bureau of Standards focuses on a process validation wafer (PVW) concept which is intended to evaluate process and circuit parameter uniformity, and to measure the occurrence of random faults such as pin holes, multi-contact resistance, and emitter-collector pipes. The PVW is an entire wafer of test structures and is intended to be fabricated along with product wafers on a periodic basis. As a process characterization tool, it can be used to qualify vendors and can serve as a circuit acceptance criterion. This concept has the potential of greatly reducing the user-imposed requirements that now accompany a high-reliability component purchase.

16621. Smith, W. W., Gilbert, D. A., Peterson, C. W., **Vacuum ultraviolet emission spectra from keV energy rare gas ion-atom collisions,** (Proc. 4th Int. Conf. on Beam Foil Spectroscopy, Gatlinburg, TN, Sept. 15-19, 1975), Paper in *Beam-Foil Spectroscopy,* I. A. Sellin and D. J. Pegg, Eds., **2,** 695-704 (Plenum Press, New York, NY, 1976).

Key words: electron-promotion model; ion-atom collisions; solar corona; vacuum ultraviolet emission spectra; vacuum ultraviolet lasers.

Emission spectra have been observed under single-collision conditions in the 500-1100 Å wavelength range and 10-30 keV ion beam energy range for collisions of $(He^+, Ne^+, Ar^+) + Ar$, as well as $Ar^+ + Ne$, $Ar^+ + He$ and $Ne^+ + Ne$. The Ar I and Ar II spectra observed with an argon gas target are similar to those observed previously with $He^+ + Ar$ by de Heer and by Isler, except that with $Ar^+ + Ar$ excitation both the Ar I 4s resonance lines and the 3d-3p transitions in the Ar I spectrum are relatively more prominent than with the other projectiles. A striking difference is found between the strong excitation of the 920 and 932 Å lines of Ar II by a Ne^+ beam on Ar (cross section $\sim 7 \times 10^{-17}$ cm^2 at 30 keV) compared with weak excitation of these lines using $Ar^+ + Ne$ in the same energy range. With $Ne^+ + Ne$, the most prominent lines observed were the 3s and 4s resonance lines of Ne I. Approximate absolute emission cross sections are given for a number of lines. The results are discussed in terms of the electron-promotion (molecular orbital) model of ion-atom collisions. This work may have applications to excitation processes in the solar corona and in vacuum uv lasers.

16622. Wacker, P. F., **Quantifying hazardous microwave fields: Analysis,** *Proc. Symp. on the Biological Effects and Health Implications of Microwave Radiation, Richmond, VA, Sept. 17-19, 1969, BRH/DBE 70-2,* 197-203 (U.S. Department of Health, Education, and Welfare, Rockville, MD, June 1970).

Key words: hazardous microwave fields.

The existing standards for microwave radiation hazards are based upon far-field concepts which may have little or even no validity in near fields. However, hazards occur largely in near fields, and even many dosimetry experiments are carried out in near fields. Because of the great complexity possible in a near field, a probe should, in principle, simulate the individual who might be subject to the possible hazard; however, such a probe is not feasible. Electric energy density provides a reasonable index of a large class of microwave radiation hazards and is simpler to measure in a near field than is energy flow. Analytical aspects of near field measurements are discussed in general, and design of a possible probe described in detail.

16623. Freund, S. M., Sweger, D. M., Travis, J. C., **Quantitative detection of nitrogen dioxide in nitrogen using laser magnetic resonance at 1616 cm^{-1},** *Anal. Chem.* **48,** No. 13, 1944-1946 (Nov. 1976).

Key words: infrared detection; laser magnetic resonance; modulated absorption; nitrogen dioxide; NO_x detection; quantitative detection.

The selective, quantitative detection of nitrogen dioxide in part-per-million concentrations in nitrogen using magnetic field modulation of the molecular absorption of 1616 cm^{-1} carbon monoxide laser radiation is reported. A magnetic field of less than 500 gauss is sufficient to shift the infrared transition of interest into coincidence with the laser. The Zeeman-modulated absorption of the laser light is synchronously detected, and is found to vary linearly with NO_2 concentration over the two orders of magnitude investigated. The synchronous detection scheme discriminates against nonparamagnetic species, such as water and ethylene, which could interfere with direct absorption measurements.

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16624. Conti, D. M., **A method for estimating service bureau processing charges,** *Proc. 7th Int. Conf. of the Computer Measurement Group, Inc., Atlanta, GA, Nov. 16-19, 1976*, pp. 34-60 (Computer Measurement Group, Camp Springs, MD, Nov. 1976).

Key words: benchmarking; charging algorithms; service bureaus; synthetic benchmarking; workload characterization.

This paper describes the development of a new synthetic benchmark technique for estimating batch processing charges at service bureau sites. This technique was used to estimate the cost of processing a large batch workload at a number of service bureaus within the same vendor line. The method was found to be low-cost, yet reasonably accurate for a certain class of service bureau charging algorithms. Refinements of this method are suggested which will extend its applicability to other algorithms. The procedures used to create and run the benchmark, together with the projection of total workload costs are described.

16625. McMichael, J. M., Mease, N. E., **On the application of tension to compliant membranes,** *AIAA J. Tech. Notes* **14,** No. 10, 1490-1492 (Oct. 1976).

Key words: air impedance; compliant surface; drag reduction; membranes; tension; vibrating membranes.

In connection with a study of the feasibility of achieving drag reduction by the use of compliant surfaces in turbulent boundary-layers, a method of applying tension to rectangular compliant membranes by the use of suction in chambers adjacent to the free membrane area has been developed. A description of the method is presented along with data evaluating the method. Measurements of the impedance effect of the ambient air on the frequencies of the normal modes of vibration are also presented.

16626. Penn, R. W., Fong, J. T., Kearsley, E. A., **Experience in data acquisition and reduction for a biaxial mechanical testing program,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 613, Use of Computers in the Fatigue Laboratory*, pp. 78-93 (American Society for Testing and Materials, Philadelphia, PA, 1976).

Key words: biaxial; fatigue; fracture; laboratory automation; mechanical testing; plasticity; polyvinyl chloride; servo-hydraulic system; viscoelasticity; yield point.

The inadequacy of uniaxial mechanical testing data as a basis for predicting multiaxial deformation and fracture is well known. For optimal biaxial tests, computer control of simultaneous variation of loadings using hydraulic power under closed loop servocontrol is essential. Computer assistance in real time data reduction from a biaxial mechanical test is economical. Physical features of computer hardware, software, and a hydraulic biaxial system are described along with sample results illustrating cross effects in fatigue and yield surface calculations. Significance of the graphical output based on thin tube specimens of 1-in. (2.54-cm) nominal diameter, schedule 80, commercial grade polyvinyl chloride pipes, and the limitations of the present system are discussed.

16627. Truhlar, D. G., Merrick, J. A., Duff, J. W., **Comparison of trajectory calculations, transition state theory, quantum mechanical reaction probabilities, and rate constants for the collinear reaction $H + Cl_2 \rightarrow HCl + Cl$,** *J. Am. Chem. Soc.* **98,** 22, 6771-6783 (Oct. 27, 1976).

Key words: chemical reactions; chlorine molecules; classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; trajectories; transition-state theory.

Quantum mechanical rate constants are computed for the collinear reaction $H + Cl_2 \rightarrow HCl + Cl$ using the reaction probabilities of Baer. For comparison we also computed reaction probabilities and rate constants for this reaction using (a) the quasiclassical trajectory method, (b) the reverse quasiclassical trajectory method, (c) the classical S matrix theory (using real-valued trajectories only), and (d) transition-state theory assuming separability of the reaction coordinate at the transition state. Comparisons are made not only for total reaction probability and total rate constant but also in general for state-to-state reaction probabilities and state-to-state rate constants. The quasiclassical trajectory method is generally accurate except in the threshold regions for various state-to-state processes. It is more accurate for total reaction probabilities and total rate constants than for state-to-state reaction probabilities and rate constants. The quasiclassical trajectory calculations of total rate constants for reaction in a given initial vibrational state agree with the quantum calculations within 29 percent for the 300-1000 K temperature range but the state-to-state rate constants may be in error by a factor of 2 or more even for processes which are classically allowed in the sense of classical S matrix theory. Classical S matrix theory does not always provide a more accurate way to extract state-to-state reaction probabilities from these trajectories. Transition state theory (which yields average reaction probabilities and total rate constants for a thermal distribution of initial states but does not yield state-to-state results) is fairly accurate for this reaction even with the assumption that the reaction coordinate is separable.

16628. Parris, G. E., Brinckman, F. E., **Reactions which relate to environmental mobility of arsenic and antimony. II. Oxidation of trimethylarsine and trimethylstibine,** *Environ. Sci. Technol.* **10,** No. 12, 1128-1134 (Nov. 1976).

Key words: antimony; antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine.

Oxidation of trimethylarsine and trimethylstibine by atmospheric oxygen and other reagents is examined, and semiquantitative rate constants are calculated. In methanol solution the rate constant for reaction of dissolved oxygen with trimethylstibine is greater than 10^{-2} M^{-1} s^{-1}, whereas for the oxidation of trimethylarsine, the rate constant is less than 10^{-2} M^{-1} s^{-1}. In the gas phase the rate constants are estimated as 10^{3} and 10^{-6} M^{-1} s^{-1} for reaction of trimethylstibine and trimethylarsine, respectively, with oxygen. A scheme based on PMR evidence for reactive intermediates is suggested to account for the products of oxidation, $(CH_3)_3EO$ and $(CH_3)_2EO_2H$, of these compounds $(CH_3)_3E$,E = Sb, As. From these results, even if biological methylation of antimony occurs in nature analogous to that of arsenic, the rapidity with which $(CH_3)_3Sb$ is oxidized would probably prevent hazardous concentrations from building up in aerated surroundings.

16628A. Parris, G. E., Brinckman, F. E., **Reactions which relate to the environmental mobility of arsenic and antimony. I. Quaternization of trimethylarsine and trimethylstibine,** *J. Org. Chem. Notes* **40,** No. 25, 3801–3803 (1975).

Key words: alkyl halides; antimony; arsenic; environment; kinetics; methylation; nucleophilic reactivity; onium salts; polar solvents; pollutants; quaternization.

The quarternization reactions of trimethylstibine and trimethylarsine with CH_3I, CH_3CH_2I and $CH_3CH_2CH_2I$ to produce the corresponding stibonium and arsonium salts have been studied in methanol and acetonitrile solvents. The reactions are of the S_N2 type. Trimethylarsine reacts about ten times as fast as trimethylstibine and the reactions are about five times faster in acetonitrile than in methanol. The reactivity of the alkyl halides is $CH_3I >> CH_3CH_2I > CH_3CH_2CH_2I$. It is suggested that quaternization is one of several reactions which potentially effects the mobilization of antimony and arsenic in environmental situations.

16629. Voth, R. O., Hord, J., **Economics of cryocables,** *Int. J. Hydrogen Energy* **1,** 271-289 (1976).

Key words: a.c. power; cryoresistive; energy transmission economics; helium; hydrogen energy; liquid hydrogen; liquid nitrogen; power transmission cables; safety; slush hydrogen; superconducting.

This paper examines the technical and economic feasibilities of: (1) using cryogenic hydrogen to cool a.c. cryoresistive or a.c. superconducting power transmission cables and, (2) delivering liquid hydrogen concurrently with cryoresistive or superconducting electrical power through a common cable. Cryogenic hydrogen coolant options considered are subcooled liquid and slush. Cryogenic nitrogen and helium coolants are also considered for cryoresistive and superconducting cables, respectively, to provide reference data for comparison with our H_2-coolant calculations. Thermodynamic analyses are performed to optimize the coolant flow rate and refrigerator spacing for each specific coolant, coolant fluid state, cable design, cable insulation quality and energy delivery option. The use of hydrogen as a coolant in electrical cables is discussed from a safety viewpoint.

Helium-cooled and hydrogen-cooled superconducting power transmission lines are shown to be economically competitive and offer lower unit-transmission costs than conventional underground power lines. The hybrid hydrogen-superconducting cable concurrently transmits liquid hydrogen and electricity at the lowest unit cost of all cryocable energy systems examined. Hydrogen-cooled power lines and hybrid hydrogen-electric energy cables appear to be technically and economically feasible; however, they do not currently provide sufficient economic incentive to warrant the increased hazard of operation.

16630. Kusuda, T., **Procedure employed by the ASHRAE Task Group for the determination of heating and cooling loads for building energy analysis,** *ASHRAE Trans.* **82,** Pt. 1, 305-322 (1976).

Key words: algorithm; ASHRAE; buildings; computer; energy calculation; heat transfer; heating and cooling loads; response factor.

Most up-to-date thermal load calculation methodology recommended by the ASHRAE Task Group on Energy Requirements is based upon an exact solution of the heat exchange equations among the room surfaces, room furnishings, lighting fixtures, equipment, occupants, and room air. Simplified calculation procedures are possible by the use of transfer functions or by a linear regression equation which could be derived from the rigorous calculation. Although the simplified solutions are entirely adequate for the energy calculation of conventional residential buildings or buildings which do not have the multiplicity of zones and complex air side systems, an exact and rigorous calculation method has a few advantages, some of which were discussed in the main text.

The advantages or the uniqueness of exact calculation procedures are to assist engineers who are willing to explore various energy conservation features or innovative building designs such as the use of interior mass of the building for the storage of off-peak cooling, nighttime setback of the thermostat, flushing of the building with cool night air and the critical matching of the equipment with the indoor comfort requirements.

Although the exact method may appear formidable from the standpoint of algorithmic complexity as compared to the simplified steady state calculation, the use of computer programs which employ such a method will become much easier as the programming technique improves and as more computers are made larger, faster and more readily accessible in the near future.

Only the comprehensive load calculation methodology prepared by the ASHRAE Task Group on Energy Requirements enables the engineer to take advantage of the rapidly growing computer technology to meet the challenges of innovative building design.

16631. Diller, D. E., **Thermophysical properties data research on compressed and liquefied gases at the NBS Cryogenics Division,** (Proc. Cryogenic Engineering Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper M-7 in *Advances in Cryogenic Engineering* **21,** 522-531 (Plenum Press, New York, NY, 1976).

Key words: density; dielectric constant; electromagnetic properties; equation of state; ethane; hydrocarbon; liquefied natural gas; measurements; methane; mixtures; thermodynamic.

This report summarizes important NBS contributions to accurate thermophysical properties data from compressed and liquefied gases (helium, hydrogen, nitrogen, oxygen, fluorine and argon), and discusses research on liquefied hydrocarbon gases (methane, ethane, ethylene, etc.) and their mixtures. Representative results of research on the thermophysical properties of methane and mixtures containing methane are presented. Additional contributions expected through 1977 are summarized.

16632. Fickett, F. R., **Magnetic and electrical properties of internally oxidized CuFe alloys,** (Proc. Joint MMM-Intermag Conf., Pittsburgh, PA, June 15-18, 1976), *AIP Conf. Proc. No. 34, Magnetism and Magnetic Materials—1976,* J. J. Becker and G. H. Lander, Eds., pp. 25-26 (American Institute of Physics, New York, NY, 1976).

Key words: alloy; copper; cryogenic; iron; oxide; resistivity; remanance; susceptibility.

A series of CuFe alloys containing 1-100 at. ppm Fe has been internally oxidized. In nearly all cases the specimens become ferromagnetic. We have measured the remanent moment and low field susceptibility at room temperature, and the electrical resistivity at 273 K and 4 K. These data combined with Curie temperature measurements and scanning electron microscopy indicate the presence of very small single domain grains of copper ferrite within the copper matrix. The annealing process appears to be capable of sweeping most of the iron impurities from the matrix in spite of their very low concentrations.

16633. Daney, D. E., **Low-temperature losses in supercritical helium refrigerators,** (Proc. Cryogenic Engineering Conf., Kingston, Ontario, Canada, July 22-25, 1975), Paper E-4 in *Advances in Cryogenic Engineering* **21,** 205-212 (Plenum Press, New York, NY, 1976).

Key words: Brayton cycle; cryogenic refrigeration; refrigeration; superconducting transmission lines.

A comparison is made of the efficiencies of the low temperature portion of three alternative schemes of supercritical helium refrigeration for higher temperature superconducting transmission lines. The range of transmission line operating conditions considered is load pressures from 3 to 20 atm and load temperatures from 8 to 14 K. The analysis indicates that no single scheme demonstrates a marked superiority at higher pressures, and that the use of a low temperature pump does not greatly reduce the system efficiency at higher pressures.

16634. Arvidson, J. M., Hord, J., Mann, D. B., **Dispersion of hydrogen or methane fuels released into an automobile interior,** (Proc. Cryogenic Engineering Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975),

Paper J-3 in *Advances in Cryogenic Engineering* **21,** 387-398 (Plenum Press, New York, NY, 1976).

Key words: automobile; detection; dispersion; explosion; fire; hydrogen; leakage; methane; safety; vents.

Gasoline-powered automobiles are being converted to operate on gaseous fuels such as hydrogen (H_2) or methane (CH_4). The fuel is often stored as a cryogenic liquid (H_2 at 20 K and CH_4 at 112 K) in dewar-like vessels located in the trunk of the car. Cryogenic storage provides four to five times greater vehicle range than gas storage in high pressure cylinders of comparable volume. Potential leakage of these gaseous fuels into the passenger compartment of the vehicle constitutes a safety threat. Definitive experiments were performed to identify the explosion hazards and establish venting criteria and general safe-guards for H_2 or CH_4 fueled passenger vehicles. Initial tests were conducted using methane at three inlet temperatures (300, 200, and 121 K) and it was determined that the gas dispersion patterns were not temperature dependent. Appropriately designed ventilation systems can significantly reduce the safety hazards associated with accumulated combustible gases. Vents are recommended for all autos converted to burn H_2 or CH_4 and may possibly be eliminated in new cars that are designed for gaseous fuel operation. Combustible gas warning systems are recommended, at least in the interim, for all (converted and new-design) gaseous fueled vehicles. H_2 and CH_4 gases appear equally safe as vehicular fuels if used in properly designed vehicles.

16635. Ledbetter, H. M., Moment, R. L., **Elastic properties of face-centered-cubic plutonium,** *Acta Met.* **24,** No. 10, 891-899 (Oct. 1976).

Key words: bulk modulus; compressibility; Debye temperature; elastic constants; plutonium; plutonium alloy; Poisson ratio; shear modulus; sound velocity; Young modulus.

The three principal elastic constants, C_{ij}, of f.c.c. plutonium were determined by measuring the ultrasonic wave velocities along a near−6110⟩ direction in a single crystal. The elastic anisotropy is twice that known for any other f.c.c. metal. The elastic-anisotropy problem is considered using a general two-body central-force interatomic potential. Based on the C_{ij}, polar plots of the wave velocities and Young's modulus were determined. The C_{ij} were "averaged" to obtain quasi-isotropic elastic constants, which are compared with existing polycrystalline elastic data. The elastic Debye temperature was computed by numerically integrating the Christoffel equations.

16636. Clark, A. F., **Stress effects in superconductors,** *Cryogenics* **16,** No. 10, 632-633 (Oct. 1976).

Key words: critical current; mechanical properties; stress effects; superconductors; symposium.

A one day symposium on stress effects in superconductors is summarized.

16637. Parrish, W. R., Hiza, M. J., **On the consistency of liquid-vapor equilibria data for binary mixtures on methane with the light paraffin hydrocarbons,** (Proc. Cryogenic Engineering Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper M-2 in *Advances in Cryogenic Engineering* **21,** 485-492 (Plenum Press, New York, NY, 1976).

Key words: critical loci; excess Gibbs' energies; Henry's constants; liquid-vapor equilibria; methane-light hydrocarbon binary mixtures.

Published experimental liquid-vapor equilibria data for the binary systems of methane with ethane, propane, isobutane, and normal butane have been compiled and evaluated for internal and mutual consistency. Equimolar excess Gibbs energies and infinite dilution Henry's constants are obtained by a method which uses only $P - x$ data. The derived equimolar excess Gibbs energies are compared with those calculated from a modified hard-sphere model for the equimolar mixtures. Critical loci (P_c, T_c, x_c) are also examined where available. Discrepancies in the data are enumerated which suggest the desirability of more precise and accurate measurements.

16638. Siegwarth, J. D., Holste, J. C., Morrow, A. J., **Polarization and dielectric constant of potassium tantalate,** *J. Appl. Phys.* **47,** No. 11, 4791-4793 (Nov. 1976).

Key words: dielectric constant; dielectric relaxation; electret; polarization; potassium tantalate.

The polarization of $KTaO_3$ single crystal and some $KTaO_3$ ceramic specimens has been measured using a dc technique. A remanent polarization was found as well as hysteresis in the polarization as a function of field. Peaks in the ac dielectric constant were also observed. These dielectric properties are attributed to dielectric relaxation effects and the existence of an electret state.

16639. Siegwarth, J. D., Morrow, A. J., **Low-temperature polarization in impure $SrTiO_3$ ceramics,** *J. Appl. Phys.* **47,** No. 11, 4784-4790 (Nov. 1976).

Key words: dielectric relaxation; electret state; impurity; ordering transition; polarization; remanent; strontium titanate.

Measurements of the temperature dependence of the dielectric constant and polarization in a constant field have been made on nominally pure $SrTiO_3$ ceramics and $SrTiO_3$ ceramics containing vanadium and niobium impurities. The peaks in the dielectric constant and the remanent polarization observed are apparently not due to a ferroelectric or antiferroelectric transition but rather to the presence of a thermoelectret state existing for permanent dipoles in the materials. It is suggested that the permanent dipoles have an origin similar to the impurity-vacancy dipoles found in alkali halides.

16640. Fowlkes, C. W., Tobler, R. L., **Fracture testing and results for a Ti-6Al-4V alloy at liquid helium temperature,** *Eng. Fract. Mech.* **8, 487-500 (1976).**

Key words: crack propagation; cryostats; fracture tests; low temperature tests; mechanical tests; titanium alloys.

This paper discusses fracture toughness and fatigue crack growth testing at liquid helium temperature, 4 K (− 452 °F). The design and performance of a fracture testing cryostat and associated instrumentation are described. Fracture toughness and fatigue crack growth data for Ti-6Al-4V from room temperature to 4 K are presented.

16641. Jespersen, J. L., **Topside spread-F and satellite radio scintillations,** (Proc. 10th Annual Symp. of the Ionospheric Research Committee of the Avionics Panel of AGARD/NATO, Rome, Italy, Sept. 21-25, 1965), Chapter 3-9 in *AGARD Conference Proceedings 3, Propagation Factors in Space Communications,* pp. 203-207 (Technivision, Maidenhead, England, 1967).

Key words: absorption; high latitude; ionosphere; ionospheric scattering; irregularity; satellite; scintillation; spread-F; topside.

Over the last decade many workers have studied the relation between spread-*F*, detected by ground-based ionospheric sounders, and the scintillation of a radio signal either from a radio star

or from an artificial earth satellite. In this paper the relation between scintillations and spread-*F* detected by the topside sounder satellite, *Alouette I*, near College, Alaska, is studied. The scintillations are correlated with small-scale irregularities in the vicinity of the satellite. This supports the view that high-latitude irregularities extend from near h_{max} to as high as 1000 km. Simultaneous topside and bottomside soundings of the ionosphere, taken together with the scintillation observations, suggest that on occasion the ionospheric disturbance, associated with the irregularities, extends below h_{mac} into the *D* region.

16642. Smith, R. V., **Fluid dynamics,** Chapter 5 in *Cryogenic Fundamentals*, pp. 237-310 (Academic Press, New York, NY, 1971).

Key words: compressibility flow; cryogenics; fluid dynamics; pressure drop; superfluid helium; two phase flow.

This chapter reviews the field of fluid dynamics with special emphasis on the behavior of cryogenic fluids.

16643. Peterson, R. L., **The magnetophonon effect,** Chapter 4 in *Semiconductors and Semimetals* **10,** *Transport Phenomena*, R. K. Willardson and A. C. Beer, Eds., pp. 221-289 (Academic Press, New York, NY, 1975).

Key words: magnetophonon effect; semiconductors; transport theory.

This article is a comprehensive review of the magnetophonon effect. All theoretical and experimental articles published to date are referenced and discussed. An attempt is made to point out the weaknesses and unique contributions of the various publications. A broad overview, and a discussion of uncompleted work and likely areas for new efforts, are also given so that both the casual reader and the serious researcher will be benefitted.

16644. Jespersen, J. L., Gatterer, L. E., Hanson, D. W., Hamilton, W. F., **Artificial satellites as a means of time dissemination,** *Proc. Int. Conf. on Space and Communications, Paris, France, Mar. 29-Apr. 2, 1971, Paper 16 D*, pp. 426-433 (L'Espace et la Communication Observation: Metrologie, Geodesia Localisation, Paris, France 1971).

Key words: communication satellite; communication system; hf time dissemination services; navigation system; satellite time and frequency dissemination services.

Satellite time and frequency dissemination systems offer certain advantages over conventional HF broadcast services. Some of the important deficiencies of HF broadcasts are discussed together with the corresponding advantages of satellite systems. Experimental results obtained at NBS using UHF/VHF satellite transponders are reviewed. Work performed by other experimenters at higher frequencies is described.

The relationship of disseminated time and frequency to the design and operation of navigation and communication systems is described. There are significant advantages to relating the time and frequency information disseminated incidental to navigation and communication system operation to external standards.

16645. Haynes, W. M., Hiza, M. J., Frederick, N. V., **Magnetic suspension densimeter for measurements on fluids of cryogenic interest,** *Rev. Sci. Instrum* **47,** No. 10, 1237-1250 (Oct. 1976).

Key words: apparatus; density; experimental; magnetic suspension; methane; nitrogen; saturated liquid; tables.

An apparatus incorporating a magnetic suspension technique has been developed for density measurements on liquids and liquid mixtures, particularly at saturation, at temperatures between 90 and 300 K and at pressures to 5 MPa (approximately 50 atm). The feasibility of adapting this method, previously used at room temperature, for low temperature use had been demonstrated in an earlier study with a density measurement on saturated liquid nitrogen near its normal boiling point. The present apparatus, which is significantly improved, and in most respects different from the earlier model, is described in detail. It includes a cryostat for continuous wide-range temperature control, a windowed equilibrium cell particularly suited for studies of liquid mixtures, and a new electronic servocircuit with a linear differential transformer for position control of the magnetic buoy. Extensive tests and density measurements have been carried out to evaluate the performance of this apparatus. Densities of saturated liquid nitrogen between 95 and 120 K and saturated liquid methane between 105 and 160 K are reported. The estimated standard deviation of a single density measurement is less than 0.02 percent. The total systematic error in the measurement process from known sources is approximately 0.05 percent. The total uncertainty of a single density measurement, which is taken as three times the standard deviation plus the systematic error, is approximately 0.1 percent. Comprehensive comparisons of the present results with previous experimental data are presented.

16646. Haynes, W. M., Hiza, M. J., **Orthobaric liquid densities of normal butane from 135 to 300 K as determined with a magnetic suspension densimeter,** (Proc. Cryogenic Engineering, Conf., Advances in Cryogenic Engineering, Kingston, Ontario, Canada, July 22-25, 1975), Paper M-6 in *Advances in Cryogenic Engineering* **21,** 516-521 (Plenum Press, New York, NY, 1976).

Key words: density; experimental; magnetic suspension densimeter; normal butane; saturated liquid; table.

A magnetic suspension densimeter, developed for absolute density measurements of the principal components of liquefied natural gas and their mixtures, has been used to determine the orthobaric (saturated) liquid densities of normal butane from 135 to 300 K. These measurements provide the first set of density data for liquid-*n*-butane that spans the range of temperatures from near ambient to just above the triple point, 134.8 K. These new data have been fitted to a simple analytical expression to provide a convenient and precise interpolation method. This equation has also been used to calculate densities for the subcooled liquid region at temperatures normally associated with liquefied natural gas. The precision and repeatability of measurement is within two parts in 10,000 or better. The absolute error in the densities is estimated to be less than ± 0.1 percent.

16647. Warnar, R. B. J., **Letter to Editor on "Trends in Computer Hardware Technology," by David A. Hodges,** *Computer Design* **15,** No. 12, 14 (Dec. 1976).

Key words: cells; charge-coupled device (CCD); chevron; garnet; large-scale-integration (LSI); line width; lithography; magnetic bubble device (MB); memory storage density; N-channel metal-oxide-semiconductor (N-MOS); random-access-memory (RAM); silicon.

The December 1976 COMPUTER DESIGN magazine includes a "Letter to the Editor" from the Information Technology Division, ICST, regarding an article "Trends in Computer Hardware Technology" (COMPUTER DESIGN, February 1976, pp. 77-85). Information included in the letter was derived from the soon-to-be-published Special Publications "Foreign and Domestic Accomplishments in Magnetic Bubble Device Technology" and "Foreign and Domestic Accomplishments in Charge-Transfer Device Technology." Information included in the letter clarified certain specific statements of the February article in the areas of bit-density and cost of charge-coupled devices (CCD's) and magnetic bubble memories (MB's). Specific differences in fabrication techniques between conven-

tional LSI solid-state circuitry and CCD/MB fabrication techniques are highlighted.

16648. McLaughlin, W. L., Humphreys, J. C., Chappell, S. E., Olejnik, T. A., Fox, C. E., **Physical measurements for quality control in industrial radiation sterilization,** (Proc. Int. Conf. on Physics in Industry, Dublin, Ireland, Mar. 8-13, 1976), Paper in *Physics in Industry*, E. O'Mongain and C. P. O'Toole, Eds., pp. 567-573 (Pergamon Press, Oxford, England, 1976).

Key words: dosimetry; electron beams; gamma rays; physical measurements; quality control; radiation measurement; radiation processing; radiation sterilization; radiochromic dyes; Red Perspex; sterility control.

The use of ionizing radiation has brought about a growing industry for the sterilization of disposable surgical equipment, medical supplies, and containers for biological specimens. For many products, irradiation has become an alternative to autoclaving or gas treatment by ethylene oxide. Over fifteen years of experience with industrial sterilization by cobalt-60 gamma radiation have shown that radiation methods provide a clear advantage over gas sterilization, in that sterilization can be performed on nonpermeable sealed packages. Moreover, regulatory agencies, such as the Food and Drug Administration in the U.S.A., are reappraising the requirements for sterility assurance. For products released to the public, consideration is now being given to the use of physical dosimetry, i.e., the measurement of radiation dose by physical methods. This is based on a knowledge of the microbial burden of the product before sterilization and on the probability of killing microorganisms by a given radiation dose. Because physical dosimetry is easier to control and less complicated than biological tests, it may be considered in the future the basis for quality assurance of the sterilized product. Some of the problems associated with standardized measurement techniques in radiation sterilization include the choice of dosimetry and its calibration, as well as methods and procedures used to minimize errors due to variations in radiation flux density, source geometry with respect to the product, and environmental factors.

16649. Hall, J. L., Lee, S. A., **Control techniques for cw dye lasers,** *Proc. Conf. on Tuneable Lasers and Their Applications, Leon, Norway, June 1976*, pp. 361-366 (Springer-Verlag, Berlin, Germany, 1976).

Key words: cw dye laser; frequency control; laser wavelength determination; scanning interferometer.

Stabilized cw dye lasers are potentially a most useful spectroscopic took but they bring a troublesome technology. We list the major problems specific to these lasers. We present a stabilized dye laser design which addresses these problems successfully to produce a useful widely tuneable laser with 50 kHz spectral width and exceptional high single mode power covers 10 K efficiency (12%). An automatic interferometer system is described which gives realtime numerical laser wavelength readout of sub-Doppler absolute accuracy.

16650. Zelkowitz, M. V., **Automatic program analysis and evaluation,** *Proc. 2nd Int. Conf. on Software Engineering, San Francisco, CA, Oct. 13-15, 1976*, pp. 158-163 (IEEE Computer Society, Long Beach, CA, Oct. 1976).

Key words: dynamic analysis; errors; evaluation; program complexity; program measurement static.

There is currently considerable interest in the computing community in the evaluation of computer programming. However, in order to objectively evaluate such concepts, it is necessary to undertake a thorough evaluation of the programming process itself. Most previous studies of this type have analyzed, by hand usually, a few instances of programs. This has led to some general conjectures; however, the amount of information that must be processed precludes any large scale analysis. In order to avoid this problem, an automatic data collection facility has been implemented as part of a PL/1 compiler at the University of Maryland. This system automatically collects information on each program that has been compiled—at almost no additional cost to the user of the compiler. This paper will describe the system and will evaluate some of the characteristics of some of the 25,000 programs that have been run since July, 1975.

16651. Crawford, M. L., Smart, G. R., **New coaxial thermistor mounts for use as precision transfer standards,** *Proc. Instrument Society of America Conf., Philadelphia, PA, Oct. 26-29, 1970*, No. 708-70, 1-6 (Instrument Society of America, Pittsburgh, PA, 1970).

Key words: coaxial thermistor mounts; precision transfer standards.

Improved thermistor mounts have been designed and constructed for use as precision low power transfer standards. Characteristics of these mounts which represent improvements over typical commercially available thermistor mounts are as follows: 1) Input VSWR ≤ 1.03 as compared to typical VSWR ≥ 1.1; 2) Provision for checking thermistor pair match (for similar characteristics), when dc bias is applied; 3) Use of precision 14 mm input connectors; 4) Extended frequency range from 1 MHz to 4.0 GHz and at specified frequencies from 4 to 8 GHz.

The paper describes the thermistor mount design and includes a mathematical analysis of an approximation to their equivalent circuit. Design equations and experimental results are given for the mounts along with a brief analysis of the errors.

16652. Mandel, J., **Statistical methods in analytical chemistry,** Chapter in *Treatise on Analytical Chemistry*, I. M. Kolthoff and P. M. Elving, Eds., Part III, Section C, **3**, 79-125 (John Wiley and Sons, New York, NY, 1976).

Key words: analytical chemistry; data analysis; design of experiments; statistics.

This chapter is an introduction, written mainly for the analytical chemist, to the use of statistics in designing experiments and analyzing data. Subjects covered include basic statistical concepts, precision and accuracy, interlaboratory comparisons and the Youden plot, calibration experiments, factorial experiments, analysis of structure, block experiments, comparison of test methods, control charts, confidence statements and propagation of errors. All subjects are illustrated in terms of data taken from analytical chemistry.

16653. Unassigned.

16654. Wyly, R. S., Galowin, L. S., **An approach to performance evaluation for water supply and drainage for buildings,** *Proc. CIB Commission W62 Symp., 1975, Drainage and Water Supply for Buildings, University of Glasgow, Glasgow, Scotland, Sept. 30-Oct. 1, 1975*, pp. 12/1-12/31 (1975).

Key words: acceptance protocol; performance approach; performance-based plumbing standard; performance statement; plumbing performance criteria; plumbing performance evaluation; plumbing performance.

The performance concept is reviewed as it relates to water supply and drainage for buildings.

An approach is described that is being utilized in connection with the development of a performance standard for plumbing as a complement to an updated specification-type (model) code of practice (National Plumbing Code) under the procedures of the American National Standards Institute.

The recommendation is made that the work in connection with the National Plumbing Code program include first a comprehensive review of existing information to identify existing performance statements, both those actually stated and those merely implied. Several examples are developed illustrating this concept.

It is concluded that the needs in further development and implementation of the performance approach include education, acceptance protocol and new research. The new research would be needed to establish definitive performance criteria, reproducible test procedures or predictive models, and systematic inspection procedures. During the period of transition to performance evaluation methodology, continued reliance will need to be placed on specification-oriented acceptance protocol, expert judgment and experience.

16655. Radebaugh, R., **He^3, He^4 refrigeration,** *Cryogenics* **11,** No. 1, 63 (Feb. 1971).

Key words: demagnetization; dilution refrigerator; helium 3; helium 4; liquid helium; mixtures; refrigeration.

A report of papers presented at the September 11, 1970 afternoon session of the IIP Commission I meeting is given. These papers are on the subjects of dilution and He^3 refrigerators.

16656. Sprowls, D. O., Summerson, T. J., Ugiansky, G. M., Epstein, S. G., Craig, H. L., Jr., **Evaluation of a proposed standard method of testing for susceptibility to stress-corrosion cracking of high-strength 7XXX series aluminum alloy products,** *Am. Soc. Test. Mater. Spec. Tech. Publ. 610, Stress Corrosion—New Approaches,* pp. 3-31 (American Society for Testing and Materials, Philadelphia, PA, Nov. 1976).

Key words: Aluminum Association; ASTM; industrial atmosphere; round robin tests; seacoast atmosphere; standard; stress-corrosion; 3.5 percent NaCl; 7XXX aluminum alloys.

A task group sponsored jointly by The Aluminum Association and the ASTM has recommended a standard method of test for susceptibility to stress-corrosion cracking (SCC) of 7XXX aluminum alloy products (ASTM G 47-76). The proposed standard is a comprehensive method that specifies the corrosive environment and period of exposure, type of test specimen and method of loading, procedures for sampling various manufactured product forms, and guidelines for interpretation of test results. Final selection of test procedures was based on round robin tests performed in nine different laboratories and 3-year exposures to the atmosphere in both seacoast and inland industrial locations. A summary of test results is given to illustrate how the relative performance of three different tempers of 7075 alloy plate can be influenced by the choice of a test specimen, differences in the outdoor atmosphere, and interlaboratory variations in performing the standard 3.5 percent sodium chloride alternate immersion test.

16657. Ritter, J. J., Freund, S. M., **CO_2 transverse excitation laser induced photochemical enrichment of carbon isotopes,** *J. Chem. Soc. Chem. Commun.*, No. 20, 811-813 (Oct. 20, 1976).

Key words: carbon isotopes; carbonyl fluoride; CO_2 laser photolysis; difluorocarbene; difluorodichloromethane; isotope ratio; nitric oxide; oxygen; tetrafluoroethylene; transverse excitation laser; 2-methyl propene.

CO_2 transverse excitation laser photolysis of mixtures of Cl_2CF_2 with O_2, NO, and $Me_2C=CH_2$ is isotopically selective for carbon and experimental evidence indicates that the reaction may involve a laser produced difluorocarbene intermediate.

16658. Kessler, K. G., **The optics program in the Optical Physics Division at NBS,** *Opt. Eng.* **12,** No. 3, p. 85 (May/June 1973).

Key words: optics; research at NBS.

Introduction to a series of papers describing optics research at NBS.

5. LISTING OF NBS PAPERS BY MAJOR SUBJECT AREA

This section provides a listing of 1976 papers organized by primary subject matter as follows:

Acoustics and Sound
Analytical Chemistry
Atomic and Molecular Studies
Building Technology
Computer Science and Technology
Health and Safety
Consumer Information and Protection
Electromagnetic Metrology
Electronic Technology
Energy Conservation and Production
Engineering, Product and Information Standards
Environmental Studies: Pollution Measurement
Failure Analysis
Fire Research
Fluids: Liquids, Gases and Plasmas
General Theoretical Chemistry and Physics
Instrumentation and Experimental Methods
Lasers and Their Applications
Low Temperature Science and Engineering
Mathematical and Statistical Methods
Measurement Science and Technology:
  Policy and State-of-the-Art Surveys
Measurement Science and Technology:
  Physical Standards and Fundamental Constants
Metrology: Physical Measurements
Nuclear Physics and Radiation Technology
Mechanics: Design, Testing and Measurement
Operations Analysis and Applications
Processing and Performance of Materials
Properties of Materials: Electronic, Magnetic and Optical
Properties of Materials: Structural and Mechanical
Properties of Materials: Thermodynamic and Transport
Standard Reference Data
Standard Reference Materials
Surfaces and Interfaces
Thermodynamics and Chemical Kinetics
Technology Incentives
Other Subjects of General Interest

It permits users of this catalog to scan the Bureau's output by major subject category. The user should bear in mind that a paper is listed once by major subject even though it might well contain other secondary subject matters of interest. The key-word index permits the reader to determine the overall context of a paper, and provides an excellent secondary reference source.

The categories currently in use for classifying NBS publications are listed below and are followed by a listing of each paper by category. Full citations (including key-words and abstracts) will be found under the appropriate publication series, which is included in the paper title. Also of use will be the key-word index (mentioned above) and the author index. See Section 6 on page 413 for information on their organization and use.

Acoustics and Sound

SP386, 1976 Edition. **Standards on noise measurements, rating schemes, and definitions: A compilation,** T. L. Quindry, Ed., *Nat. Bur. Stand. (U.S.), Spec. Publ. 386, 1976 Edition,* 84 pages (Apr. 1976) SD Catalog No. C13.10:386.

TN686. **Ultrasonic calorimeter for beam power measurements,** T. L. Zapf, M. E. Harvey, N. T. Larsen, and R. E. Stoltenberg, *Nat. Bur. Stand. (U.S.), Tech. Note 686,* 36 pages (Sept. 1976) SD Catalog No. C13.46:686.

TN931. **Environmental effects on microphones and type II sound level meters,** E. B. Magrab, Ed., *Nat. Bur. Stand. (U.S.), Tech. Note 931,* 120 pages (Oct. 1976) SD Catalog No. C13.46:931.

NBSIR 75-692. **A minicomputer-based system for the measurement and analysis of community noise,** R. L. Fisher, D. S. Blomquist, J. S. Forrer, and D. M. Corley, 106 pages (May 1975). Order from NTIS as PB250385.

NBSIR 76-1090. **Environmental effects on microphones of various constructions,** G. R. Hruska, E. B. Magrab, W. B. Penzes, 36 pages (July 1976). Order from NTIS as PB255505.

NBSIR 76-1110. **The acoustic pressure field alongside a manikin's head with a view towards *in situ* hearing aid tests,** E. D. Burnett and G. F. Kuhn, 26 pages (Aug. 1976). Order from NTIS as PB257073.

NBSIR 76-1138. **A proposed experiment to evaluate environmental dependence of the measurement of noise from medium and heavy duty trucks,** C. I. Holmer and R. D. Kilmer, 68 pages (Sept. 1976). Order from NTIS as PB259522.

NBS-GCR-75-33. **Impact noise testing and rating,** T. J. Schultz, 245 pages (Dec. 1974). Order from NTIS as COM 75-10133.

NBS-GCR-75-35. **Characterization of pavement macrotexture by profile spectral analysis,** J. M. Lawther and J. J. Henry, 93 pages (June 1974). Order from NTIS as COM 75-10341.

NBS-GCR-76-59. **Sound power measurements in reverberation chambers,** J. Tichy, M. Brien, and K. Roy, 233 pages (Jan. 1976). Order from NTIS as PB256639.

15708. Flynn, D. R., Pallett, D. S., **Simplified methods for calculating the transmission loss of two-element partitions,** *J. Acoust. Soc. Am.* **58,** No. 6, 1341-1342 (Dec. 1975).

16269. Cook, R. K., **Acoustic emissions—Researchers in Japan,** *Sci. Bull.* **1,** No. 1, 17 pages (June-Sept. 1976).

16318. Waterhouse, R. V., Cook, R. K., **Diffuse sound fields: Eigenmode and free-wave models,** *J. Acoust. Soc. Am.* **59,** No. 3, 576-581 (Mar. 1976).

16417. Grabec, I., Peterlin, A., **Acoustic emission of a crazing polymer,** *J. Polym. Sci.: Polym. Phys. Edition* **14,** 651-661 (1976).

16433. Pallett, D. S., Pierce, E. T., Toth, D. D., **A small-scale multi-purpose reverberation room,** *Appl. Acoust.* **9,** 287-302 (1976).

16573. Corliss, E. L. R., Jones, F. E., **Method for estimating the audibility and effective loudness of sirens and speech in automobiles,** *J. Acoust. Soc. Am.* **60,** No. 5, 1126-1131 (Nov. 1976).

16602. Simmons, J. A., Clough, R. B., **Theoretical aspects of acoustic emission spectral measurements,** *Proc. Eighth World Conf. on Nondestructive Testing, Cannes, France, Sept. 6-10, 1976,* pp. 1-8 (Imprimplans, Paris, France, 1976).

Analytical Chemistry

SP422. Volume I and II. **Accuracy in trace analysis: Sampling, sample handling, analysis.** Proceedings of the 7th Materials Research Symposium held at the National Bureau of Stan-

dards, Gaithersburg, MD, Oct. 7-11, 1974, P. D. LaFleur, Ed., *Nat. Bur. Stand. (U.S.), Spec. Pub. 422, Vol. I,* 645 pages, *Vol. II,* 636 pages, (Aug. 1976) SD Catalog No. C13.10:422/vol. I and II.

The need for accuracy in a regulatory agency, A. C. Kolbye, Jr., *SP422,* pp. 3-8 (Aug. 1976).

Accuracy and trace organic analyses, R. G. Lewis, *SP422,* pp. 9-34 (Aug. 1976).

Accuracy and quality control in trace element analysis, J. H. Boutwell, *SP422,* pp. 35-40 (Aug. 1976).

The role of the National Bureau of Standards Standard Reference Materials in accurate trace analysis, J. P. Cali and W. P. Reed, *SP422,* pp. 41-63 (Aug. 1976).

Interpretation of accuracy of trace element results in biological materials, G. H. Morrison, *SP422,* pp. 65-77 (Aug. 1976).

Precision and accuracy in silicate analysis, S. S. Goldich, *SP422,* pp. 79-89 (Aug. 1976).

Use and interpretation of water quality data, W. T. Sayers and W. R. Ott, *SP422,* pp. 91-107 (Aug. 1976).

Interpretation of clinical laboratory data, D. S. Young, *SP422,* pp. 109-122 (Aug. 1976).

The analyst and accuracy, F. P. Byrne, *SP422,* pp. 123-126 (Aug. 1976).

Detection of systematic errors by the analysis of precision, K. Heydorn, *SP422,* pp. 127-139 (Aug. 1976).

Detection of systematic error in routine trace analysis, D. E. King, *SP422,* pp. 141-150 (Aug. 1976).

The application of cluster analysis to trace elemental concentrations in geological and biological matrices, E. W. Stromberg and J. L. Fasching, *SP422,* pp. 151-162 (Aug. 1976).

Individual variation of trace metal content in fish, J. R. Montgomery, S. E. Kolehmainen, M. D. Banus, B. J. Bendien, J. L. Donaldson, and J. A. Ramìrez, *SP422,* pp. 163-172 (Aug. 1976).

Accuracy of chemical analysis of airborne particulates—results of an intercomparison exercise, F. Girardi, *SP422,* pp. 173-188 (Aug. 1976).

The estimation of accuracy in trace analysis. Results obtained from intercomparisons organized by the I.A.E.A., L. Górski, J. Heinonen, and O. Suschny, *SP422,* pp. 189-197 (Aug. 1976).

Accuracy assurance in the analysis of environmental samples, R. K. Skogerboe and S. R. Koirtyohann, *SP422,* pp. 199-210 (Aug. 1976).

Four-laboratory comparative instrumental nuclear analysis of the NBS Coal and Fly Ash Standard Reference Materials, J. M. Ondov, W. H. Zoller, I. Olmez, N. K. Aras, G. E. Gordon, L. A. Rancitelli, K. H. Abel, R. H. Filby, K. R. Shah, and R. C. Ragaini, *SP422,* pp. 211-223 (Aug. 1976).

Trace element studies of a selected portion of the Mahoning River system, I. Mahadeviah, E. Mooney, and R. Munteau, *SP422,* pp. 225-230 (Aug. 1976).

Analysis of 11 elements in biological material. Comparison of neutron activation analysis and atomic absorption analysis, H. Wesch and A. Bindl, *SP422,* pp. 231-238 (Aug. 1976).

Determination of zinc in environmental matrices: A comparison of results obtained by independent methods, M. Gallorini and E. Orvini, *SP422,* pp. 239-245 (Aug. 1976).

Reliability of trace metal determination in freshwater by flameless atomic absorption (graphite tube atomization) in comparison with other chemical and physical methods, R. Wagemann, *SP422,* pp. 247-265 (Aug. 1976).

The preparation and certification of trace mercury in water standard reference materials, J. R. Moody, P. J. Paulsen, T. C. Rains, and H. L. Rook, *SP422,* pp. 267-273 (Aug. 1976).

The influence of limits of laboratory accuracy and precision on the interpretation of blood lead analyses for industrial lead hygiene control, A. C. Eckert, Jr., *SP422,* pp. 275-282 (Aug. 1976).

Sampling and sample preparation at the Geological Survey of Canada—The what, why, and how, J. A. Maxwell, *SP422,* pp. 285-297 (Aug. 1976).

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A possibility of state analysis of plasma spectrometry, S. Hanamura, *SP422,* pp. 621-625 (Aug. 1976).

Preparation and analysis of aquatic-related samples, N. M. Ferguson, J. R. Lund, R. R. Rickard, and L. T. Corbin, *SP422,* pp. 627-632 (Aug. 1976).

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Trace element analysis of nickel and nickel-base alloys—a review of current methods, C. M. Davis, *SP422*, pp. 1005-1016 (Aug. 1976).

Nonuniform distribution (both micro and macro) of trace elements in high-temperature alloys, O. H. Kriege and J. Y. Marks, *SP422*, pp. 1017-1022 (Aug. 1976).

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Methodological considerations in western Lake Superior water-sediment exchange studies of some trace elements, J. E. Poldoski and G. E. Glass, *SP422*, pp. 1073-1088 (Aug. 1976).

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6. INDEXES

6.1. HOW TO USE THE INDEXES

In addition to the usual author index, a subject index is provided in the form of a permuted key work index. In this type of index the key words in each publication or paper are arranged by shifting each group of key words along the horizontal printing line so that each key word in turn has an opportunity to appear alphabetically. The user is thus able to locate papers of interest to him through the subject-related words he finds in the key word index.

The index symbols used in the author and key word indexes are explained in the following three tables. These tables also give the pages on which the abstracts of the various publication series begin.

Table A. Symbols for the Periodicals

NBS Journal of Research	Index Symbol			Issue Date	Page Number
	Vol.	Sec.	No.		
Section A	J80	A	1	January–February 1976	37
	J80	A	2	March–April 1976	38
	J80	A	3	May–June 1976	39
	J80	A	4	July–August 1976	40
	J80	A	5 & 6	September–December 1976	44
Section B	J80	B	1	January–March 1976	45
	J80	B	2	April–June 1976	46
	J80	B	3	July–September 1976	47
	J80	B	4	October–December 1976	48

Journal of Physical and Chemical Reference Data	Index Symbol		Issue Date	Page Number
	Vol.	No.		
J. Phys. Chem. Ref. Data	5	1	1976	49
	5	2	1976	50
	5	3	1976	50
	5	4	1976	51

DIMENSIONS/NBS	Index Symbol		Issue Date	Page Number
	Vol.	No.		
DIM	60	1	January 1976	52
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DIM	60	3	March 1976	52
DIM	60	4	April 1976	52
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Table B. Symbols for the Nonperiodicals

NBS Nonperiodical Series	Index Symbol	Page Number
Monographs	Monogr.	55
Handbooks	H	57
Special Publications	SP	58
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National Standard Reference Data Series	NSRDS	143
Building Science Series	BSS	144
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Product Standards	PS	149
Technical Notes	TN	150
Consumer Information Series	CIS	159
NBS Interagency Reports	NBSIR	160
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Table C. Symbols for the Papers Published by Others (1976)

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6.2. AUTHOR INDEX

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6.3. KEY WORD INDEX

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a priori error; *a priori* precision; *a posteriori* precision; chi-square test; precision; precision of analytical method; ultratrace level; accuracy; analysis of precision; *SP422*, pp. 127-139 (Aug. 1976).

a priori precision; *a posteriori* precision; chi-square test; precision; precision of analytical method; ultratrace level; accuracy; analysis of precision; *a priori* error; *SP422*, pp. 127-139 (Aug. 1976).

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Amplitude modulation; instrument landing system; modulation measurements; modulation meter; percent modulation; *16516.*

Analog-digital converter; A-scan; digitization; pattern recognition; speech spectrogram; ultrasound; *SP453*, pp. 51-59 (Oct. 1976).

Analysis; analytical chemistry; sample handling; sampling; trace analysis; accuracy; *SP422. Volume I and II.*

Analysis; ashing; blood lead; contamination; dairy products; digestion; interferences; losses; mercury; trace metal; *SP422*, pp. 661-668 (Aug. 1976).

Analysis; carbon; crud; filtration; pressurized water reactors; primary coolant; sampling; water; *SP422*, pp. 429-438 (Aug. 1976).

Analysis; diversion of nuclear materials; diversion path analysis; internal control system characterization; nuclear material safeguards; safeguards; *16536.*

Analysis; experimental; floor systems; human response; random process; spectral analysis; vibration; *TN904.*

Analysis; experimental; floor systems; human response; random process; spectral analysis; vibration; *NBSIR 75-951.*

Analysis, Hf I spectrum; hafnium, analysis of first spectrum; spectrum, Hf I; Zeeman effect, Hf I; *Monogr. 153.*

Analysis of air; atmosphere; gaseous pollutants; sampling air; accuracy and precision; air; air particulates; air pollution; *SP422*, pp. 311-320 (Aug. 1976).

Analysis of body fluids; clinical analysis; clinical chemistry; clinical sampling; enzyme analysis; storage of clinical samples; accuracy and precision; *SP422*, pp. 353-361 (Aug. 1976).

Analysis of precision; *a priori* error; *a priori* precision; *a posteriori* precision; chi-square test; precision; precision of analytical method; ultratrace level; accuracy; *SP422*, pp. 127-139 (Aug. 1976).

Analysts; apparatus; blank; contamination; environment; purity; reagents; accuracy; *SP422*, pp. 509-539 (Aug. 1976).

Analytic function; Cauchy principle value; Hilbert problem for two unknowns; singular integral equation; wave-guide boundary problem; *J. Res.* **80B** No. 3, 403-414 (1976).

Analytical bias; reference samples; silicate analysis; accuracy; *SP422*, pp. 79-89 (Aug. 1976).

Analytical blank; gas chromatography; ocean biota analysis; phthalate trace analysis; air analysis; *SP422*, pp. 701-708 (Aug. 1976).

Analytical blanks; analytical reagents; contamination control; high-purity reagents; membrane filtration; mercury cathode electrolysis; prepurification; purity definition; reagent contamination; ultrapurification; *SP422*, pp. 363-375 (Aug. 1976).

Analytical blanks; atmospheric sampling; coastal sampling; contamination of atmospheric particulate samples; sample handling; shipboard atmospheric sampling; *SP422*, pp. 377-388 (Aug. 1976).

Analytical chemistry; charged particle activation analysis; cross sections; excitation functions; fast neutron activation analysis; fast particle activation analysis; interferences; primary interference reactions; systematic errors; *SP422*, pp. 1189-1214 (Aug. 1976).

Analytical chemistry; contamination; errors; natural water; sample storage; sampling; accuracy; *SP422*, pp. 805-836 (Aug. 1976).

Analytical chemistry; curve fitting; data reduction; feature selection; multivariate analysis; optimization techniques; pattern recognition; signal processing; spectral resolution; statistics; *15964.*

Analytical chemistry; data analysis; design of experiments; statistics; *16652.*

Analytical chemistry; nomenclature; photochemistry; photometry; physical optics; radiometry; spectrometry; spectroradiometry; *16331.*

Analytical chemistry; sample handling; sampling; trace analysis; accuracy; analysis; *SP422. Volume I and II.*

Analytical chemistry; standard reference material; statistics; syndrome; accuracy; *SP422*, pp. 123-126 (Aug. 1976).

Analytical data; analytical work; critical evaluation of an analytical procedure; industrial chemical analysis; interlaboratory comparisons; sampling error; *16001.*

Analytical design; irradiation procedures; radioactivity detection systems; radiochemical separations; sampling and sample handling; accuracy and precision; activation analysis; *SP422*, pp. 1143-1155 (Aug. 1976).

Analytical error; geochemical variance; particle size distribution; particle size errors; sampling errors; trace analysis; *SP422*, pp. 421-427 (Aug. 1976).

Analytical methods; coal; environmental samples; environmental standards; fly ash; instrumental neutron activation analysis (INAA); instrumental photon activation analysis (IPAA); natural radioactivity; standard reference materials; *SP422*, pp. 211-223 (Aug. 1976).

Analytical model; dynamic analysis; dynamic loading; earthquake; energy dissipation; finite element; seismic response; structural engineering; *SP444*, pp. IV-70—IV-89 (Apr. 1976).

Analytical performance; between-run; calibration; precision; quality control; systematic error; Youden plot; *SP422*, pp. 141-150 (Aug. 1976).

Analytical predictions; constant stress rate; empirical measurements; fracture stress; slow crack growth; *16034*.

Analytical quality control; atomic absorption spectrometry; environmental analysis; fresh water analysis; intercomparisons; precision; round-robin experiments; trace element analysis; accuracy; activation analysis; air filter analysis; *SP422*, pp. 189-197 (Aug. 1976).

Analytical reagents; contamination control; high-purity reagents; membrane filtration; mercury cathode electrolysis; prepurification; purity definition; reagent contamination; ultrapurification; analytical blanks; *SP422*, pp. 363-375 (Aug. 1976).

Analytical techniques; fractional crystallization; geochemistry; isotope dilution; partial melting; rare earth elements; trace element models; volcanic rocks; *SP422*, pp. 937-949 (Aug. 1976).

Analytical work; critical evaluation of an analytical procedure; industrial chemical analysis; interlaboratory comparisons; sampling error; analytical data; *16001*.

Analyzing; gas analysis; gases; emission; monitors; standards; air pollution; *15982*.

Angle and energy distributions; charged particle spectroscopy; electron-stimulated desorption of ions (ESDIAD); field-ion microscopy (FIM); low energy electron diffraction (LEED); ultraviolet photoelectron spectroscopy (UPS); *16078*.

Angle of incidence; polarization; pulsed laser damage; thermal model; *SP435*, pp. 41-48 (Apr. 1976).

Angle standard; autocollimator; calibration; complete closure design; indexing table; least squares estimation; partial closure design; standard deviation; subdivision; variance-covariance matrix; *NBSIR 75-750*.

Angular dependence; blood; compressibility; density; distribution function; erythrocytes; hematocrit; scattering; ultrasound; *SP453*, pp. 207-212 (Oct. 1976).

Angular distribution; backscatter; charged particles; Monte Carlo; reflection; Albedo; *16097*.

Angular distribution; photoabsorption; soft x rays; subshell structure; *16386*.

Angular distributions; chemisorption; electron spectroscopy; photoemission; *15759*.

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Angular distributions; photoemission; photoionization; adsorption; *15748*.

Angular divergence; asymmetric diffraction; diffraction topography; dynamical diffraction; rocking curve; *16055*.

Angular insensitivity; fluidic device; hot wire anemometer; ion deflection device; laser Doppler anemometer; Reynolds number; *16108*.

Anharmonic crystal; computer simulation; energy transport; heat pulse; interatomic potential; molecular dynamics; second sound; shock wave; stress wave; temperature wave; thermal diffusivity; thermal relaxation; *16138*.

Anharmonic crystal; computer simulation; energy transport; heat pulse; molecular dynamics; second sound; stress pulse; temperature wave; thermal diffusivity; thermal equilibrium; thermal relaxation; *16589*.

Anharmonicities; branching ratio; charge distribution; electron scattering; quadrupole phonons; vibrational nuclei; *16507*.

Anharmonicities; branching ratios; electron scattering; phonons; reorientation effect; admixture; *16508*.

Anisotropy; chemorheology; degradation; elasticity; finite deformation; incompressible materials; permanent set; polymers; rubbers, viscoelasticity; *16339*.

Anisotropy; interface kinetics; solidification; stability; surface tension; alloys; *16213*.

Annals of Mathematical Statistics; bibliography; distribution-free methods; educational testing; mathematical statistics; multivariate analysis; order statistics; social sciences, services to; statistical education in the United States; *16114*.

Annandale; field test; gas explosion; leak detection; *16101*.

Annealing; calcium fluoride; defect pairs; equilibria; model; point defects; *15820*.

Annealing; fracture energy (γ_c); isostatic forging; kinking; microstructures; recrystallization temperature; veiling; *SP462*, pp. 87-94 (Dec. 1976).

Annotated bibliography; bibliography; building code; building regulations; collapse; failures; progressive collapse; specific resistance; abnormal loading; alternate path; *BSS67*.

Annoyance; appliance noise; health and hearing hazards; household noise; legal and community action; loudness; noise control and abatement; traffic noise; airborne and structure-borne sounds; aircraft noise intrusion; *H119*.

Anodic decomposition; cathodic decomposition; electrochemistry; inorganic bronze electrodes; metal electrodes; semiconductor electrodes; stability, surface layers; surface reactions; *SP455*, pp. 267-280 (Nov. 1976).

Anodic films; dual barrier, electrocatalysis; oxygen evolution; platinum anodes; reaction mechanism; *SP455*, pp. 259-266 (Nov. 1976).

Anodic oxidation; electrocatalysis; semiconductor electrode; tin oxide electrode; transparent electrode; adsorption; *SP455*, pp. 175-181 (Nov. 1976).

Anodic stripping voltammetry; arc emission spectroscopy; atomic absorption; environmental analyses; interlaboratory tests; neutron activation analysis; plasma emission; round robin; x-ray fluorescence; accuracy; *SP422*, pp. 199-210 (Aug. 1976).

Anodic stripping voltammetry; background current compensation; differential anodic stripping voltammetry; electrochemical analysis; twin electrode balancing; *SP422*, pp. 881-897 (Aug. 1976).

Anodic stripping voltammetry; flameless atomic absorption; interstitial water; Lake Superior chemical analysis; trace element water analysis; water filtration; water sampling apparatus; *SP422*, pp. 1073-1088 (Aug. 1976).

Antenna; calibration; Cassiopeia A; error analysis; flux density; G/T (system gain/system noise temperature); ground station; radio star; accuracy; *16499*.

Antenna; director; driven element; gain; radiation pattern; reflector; Yagi; *TN688*.

Antenna; microwave; minicomputer; radiofrequency; RF exposure; spectrum analyzer; *SP456*, pp. 203-213 (Nov. 1976).

Antenna gain, polarization and pattern; deconvolution; extrapolation; fields and antennas; *15827*.

Antenna measurements; antenna theory; scattering-matrix theory of antennas; antenna-antenna interactions; *J. Res.* **80B** No. 1, 5-51 (1976).

Antenna specifications; mobile telecommunication transmitters; RF radiation; *SP456*, pp. 199-202 (Nov. 1976).

Antenna theory; scattering-matrix theory of antennas; antenna-antenna interactions; antenna measurements; *J. Res.* **80B** No. 1, 5-51 (1976).

Antenna-antenna interactions; antenna measurements; antenna theory; scattering-matrix theory of antennas; *J. Res.* **80B** No. 1, 5-51 (1976).

Antenna-support materials; environmental degradation; guys, nonmetallic; marine atmospheres; plastics, fiber-reinforced; pultrusions; stress-rupture testing; sunlight; ultraviolet radiation; weatherability; *NBSIR 76-1069*.

Anthropometric manikin; free-field measurements; hearing aid tests; orthotelephonic response; *16033*.

Anthropometric measurements; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; structural safety; *NBSIR 76-1132*.

Anthropomorphic units; bicentennial; history of measurement; metric conversion; metric roll call; metrology; Public Law 93-380; Public Law 94-168; *16195*.

Antibodies; antigens; biological polymers; immunochemical analysis; light scattering; polymers; proteins; solid standards; *J. Res.* **80A** No. 4, 605-608 (1976).

Antiferroelectric; dielectric constant; heat capacity; lead pyroniobate; low temperature; polarization; *16527*.

Antiferromagnetic transition; antiferromagnetism; dipolar interactions; $ErPO_4$; magnetic phase diagram; Néel temperature; spin-flop; *16436*.

Antiferromagnetism; critical temperature; dipole-dipole interaction; erbium phosphate ground state; heat capacity; lattice sums; magnetic; susceptibility; *15866*.

Antiferromagnetism; dipolar interactions; $ErPO_4$; magnetic phase diagram; Néel temperature; spin-flop; antiferromagnetic transition; *16436*.

Antifriction bearings; bearing failure; bearing failure modes; bearing inspection; bearing reclamation; bearing recycling; aircraft engine bearings; *SP423*, pp. 87-91 (Apr. 1976).

Antigens; biological polymers; immunochemical analysis; light scattering; polymers; proteins; solid standards; antibodies; *J. Res.* **80A** No. 4, 605-60 , (1976).

Antimony; antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine; *16628*.

Antimony; arsenic; environment; kinetics; methylation; nucleophilic reactivity; onium salts; polar solvents; pollutants; quaternization; alkyl halides; *16628A*.

Antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine; antimony; *16628*.

Antimony oxide; bromine; bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; fabric flammability; flame retardant mechanisms; flame retardant monomers; flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; *NBS-GCR-ETIP 76-22*.

Antimony trioxide; friction; molybdenum disulfide; spin axis gas bearings; sputtered coatings; surface characterization; wear life; *SP452*, pp. 177-186 (Sept. 1976).

Antireflectance coating; bandwidth; coating design; multilayer coating; absorptance; *SP462*, pp. 221-229 (Dec. 1976).

Antireflectance coating; chalcogenide glasses; infrared optical properties; laser damage; optical absorption; optical scattering; thin-film coating; alkali halides; *SP462*, pp. 214-220 (Dec. 1976).

Antireflection coatings; attenuated total reflection; laser windows; spectroscopic; absorption; *SP462*, pp. 246-252 (Dec. 1976).

Antireflection coatings; coatings; KCl; laser damage; alkali halides; *SP462*, pp. 283-291 (Dec. 1976).

Antireflection coatings; germanium selenide; infrared laser windows; absorption; *SP462*, pp. 279-282 (Dec. 1976).

Apollo; composition; isotopic; lithium; potassium; relative; rocks; rubidium; soils; absolute; *15869*.

Apollo 17; background; cosmic-ray proton; induced radioactivity; secondary neutrons; sodium iodide detector; *15727*.

Apparatus; blank; contamination; environment; purity; reagents; accuracy; analysts; *SP422*, pp. 509-539 (Aug. 1976).

Apparatus; density; experimental; magnetic suspension; methane; nitrogen; saturated liquid; tables; *16645*.

Apparatus and methods; infrared lasers; magnetic resonance; molecular spectroscopy; NO, NO_2, pollutant detection; *16456*.

Apparel; burn injury; carpets; draperies; fabrics; flammability; heat flux; standards; tents; tests; uniforms; upholstered furniture; *16144*.

Apparel; burn injury; ease of ignition; fabrics; fire; flammability tests; garments; heat transfer; standards; *NBSIR 76-1072*.

Apparel, burn injuries; burn injuries, fabric related; burning apparel; fabric related burn injuries; *NBS-GCR-73-11*.

Apparel fabric; fabric; fire hazard; flammability testing; thermal measurements; thermodynamic properties; *NBS-GCR-73-8*.

Apparel fabrics; fabrics; fire hazards; flammability testing; ignition; skin; thermal burns; thermal measurements; *NBS-GCR-73-6*.

Apparel fabrics; fabrics; fire hazard; flammability testing; ignition; thermal burns; *NBS-GCR-73-7*.

Apparel fabrics; fabrics; fire hazard; flammability testing; skin; thermal burns; thermal measurements; *NBS-GCR-73-9*.

Apparel fabrics; fabrics; fire hazards; flammability testing; ignition; thermal burns; thermal measurements; *NBS-GCR-73-12*.

Apparel fabrics; fabrics; fire hazard; flammability testing; simulation; skin; thermal burns; *NBS-GCR-73-13*.

Apparel fabrics; fire hazard; flammability testing; heat conductivity; simulation; skin; *NBS-GCR-73-14*.

Appearance potential; autoionization; deuterated species; enthalpy of formation; ionization potential; NH_2^+; OH^+; photoionization; predissociation; Rydberg states; ammonia; *16539*.

Appearance potential; gaseous positive ions; heat of formation; ionization potential; measurement; *16205*.

Appliance noise; health and hearing hazards; household noise; legal and community action; loudness; noise control and abatement; traffic noise; airborne and structure-borne sounds; aircraft noise intrusion; annoyance; *H119*.

Appliances; behavioral science; human factors; product safety; safety; safety research; *16215*.

Application of six-port junction concept; automated measurements; broadband measurements; microwave measurements; microwave power measurements; one-port parameters; six-port junction; *16501*.

Application of standards; basic standards; cesium standards; frequency accuracy; frequency stability; frequency standards; hydrogen standards; ion storage; laser stabilization; rubidium standards; saturated absorption; time standards; *15736*.

Application temperature; asphalt; built-up roofing; interply thickness; roofing membranes; viscosity; *BSS92*.

Applied microeconomic framework; commodity supply crisis; econometric analysis; economic impacts; efficiency impacts; income distribution effects; policy alternatives; *NBS-GCR-ETIP 76-24*.

Applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; R & D incentives; tissue characterization; tissue signature; ultrasonic diagnosis; ultrasound; *SP453*, pp. 7-10 (Oct. 1976).

Aquatic insects; atomic absorption; clean room; fish; mini-computer; sample preparation; toxic metals; trace determination; *SP422*, pp. 627-632 (Aug. 1976).

Aqueous; computer programs; data evaluation; electrolytes; electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic properties; vapor pressure; activity coefficients; *TN928*.

Aqueous systems; bibliography; biochemical systems; enthalpy data; entropy data; equilibrium data; Gibbs energy data; heat capacity data; partial molal properties; thermochemistry; thermodynamics; review articles; water pollution; *SP454*.

Ar metastable interactions; $ClHCl^-$; emission spectrum; HAr_n^+; $HCCl_2^+$; $HCCl_2^-$; $HCCl_3$; infrared spectrum; matrix isolation; molecular rotation in solid Ar; photoinduced proton transfer; ultraviolet spectrum; *15757*.

Aramid fiber rope; breaking load, rope; cable, aramid-fiber; end fittings, rope; fatigue damage; rope, aramid-fiber; slings, cargo; terminations, rope; weathering, simulated; *NBSIR 76-1159*.

Arc emission spectroscopy; atomic absorption; environmental analyses; interlaboratory tests; neutron activation analysis; plasma emission; round robin; x-ray fluorescence; accuracy; anodic stripping voltammetry; *SP422*, pp. 199-210 (Aug. 1976).

Arc-connectedness; Carlson-Johnson conjecture; *D*-stable; positive stable matrix; *J. Res.* **80B** No. 1, 75-77 (1976).

Architectural acoustics; building acoustics; sound reduction index; sound transmission loss; transmission loss; airborne sound transmission; *15708*.

Architectural glass products; Consumer Product Safety Act; residence-related products; residential safety modification; safety implementation approaches; *16006*.

Architectural glass products; Consumer Product Safety Act; residence-related products; residential safety modification; safety implementation approaches; *NBSIR 75-791*.

Architectural glazing; codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law; *NBSIR 76-1109*.

Architectural heritage; fire; guardrail; high-capacity; mathematics; mercury; performance standard; pressure transducers; SRM; surgical implants; testing; thermal transients; *DIM/NBS* **60**, No. 8, 1-24 (1976).

Architectural indexing systems; architecture; building; construction; design; information; information retrieval system; *NBSIR 76-1064*.

Architectural psychology; architectural research; building research; building safety; perception; stair safety research; *NBSIR 76-1046*.

Architectural research; building research; building safety; perception; stair safety research; architectural psychology; *NBSIR 76-1046*.

Architectural-design teaching; assemblage; design critiques; feedback; teaching method; *16020*.

Architecture; building; construction; design; information; information retrieval system; architectural indexing systems; *NBSIR 76-1064*.

Architecture; buildings; design; energy; legislation; solar; State; *NBSIR 76-1082*.

Arcing/sparking; branch circuit; contact resistance; electrical connections; fire hazard; glowing electrical connections; *NBSIR 76-1011*.

Argon; atomic transition probabilities; beryllium; boron; carbon; chlorine; helium; hydrogen; lithium; magnesium; nitrogen; oxygen potassium; sodium; aluminum; *16164*.

Argon; bulk viscosity; density expansion; methane; modified Enskog theory; molecular correlations; nitrogen; sound absorption; *16483*.

Argon; calibration; detector, radioactive argon; ionization chamber; sodium-22; standard reference materials; *16325*.

Argon; hydrogen; ionized gases; nitrogen; oxygen; thermodynamic properties; air; *16167*.

Argon oxide; collision-induced emission; rare-gas oxide excimers; ab initio potentials; *15868*.

Argon-37; atmospheric mixing; blank corrections; cosmic ray reactions; effectively zero background; environmental radioactivity; low-level counting statistics; radioactive rare gases; reduced activity; *16345*.

Argon-37; direct standardization; environmental radioactivity; internal gas counters; isotope separator; krypton-85; proportional counters; radioactivity standardization; xenon-133, 131m; *15948*.

Arithmetic average; autocorrelation function; average wavelength; kurtosis; minicomputer software; random error; skewness; surface microtopography; surface roughness; surface texture; systematic error; amplitude density function; *TN902*.

Arithmetic average; autocorrelation function; linear least-squares fit; machine language; minicomputer software; surface texture measurement; amplitude density function; *NBSIR 75-924*.

Armor; ballistic helmet; ballistic impact; ballistic penetration; bulletproof helmet; *16295*.

Aroclor; chlorinated biphenyl; chlorinated naphthalene; electric field measurement; electro-optic; high voltage measurement; Kerr coefficients; Kerr effect; space charge; *16384*.

Aromatic amine; benzene derivative; charge-transfer complex; dental materials; electron affinity; electron spin resonance spectroscopy; extrathermodynamic relationships; ionization potential; linear free-energy relationship; *J. Res.* **80A** No. 2, 173-187 (1976).

Aromatic asphaltenes; caking; coal gasification; liquefaction processes; *16365*.

Arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine; antimony; antimony oxide; *16628*.

Arsenic; atomic absorption; atomic spectrometry; background, correction; nonflame, atomization; stray light; xenon-mercury, arc lamp; *15894*.

Arsenic; evironment; kinetics; methylation; nucleophilic reactivity; onium slats; polar solvents; pollutants; quaternization; alkyl halides; antimony; *16628A*.

Arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine; antimony; antimony oxide; arsenic; *16628*.

Arsenic trisulphide; ion planing; protective films; moisture resistance; sodium chloride; *SP435*, pp. 14-19 (Apr. 1976).

Arson; firesetting; psychopathic personality; *15837*.

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Artificial intelligence; automation; computer control; manipulators; robots; robot systems; *16047*.

Aryl phosphines; cyclic voltammetry; desulfurization; phosphines; tetracyanotetrathiafulvalene; tetracyanotetrathiafulvalene-triphenylphosphine; $\Delta^{2,2'}$-bis-14.5-dicyano-1,3-dithiodene; 1,3-dithiolenes; ^{31}P NMR; *15991*.

Ar-37; atmospheric radioactivity; cosmic-ray reactions; exponential distribution; low-level counting; noble gas separation; on-line computer; pulse shape discrimination; tropospheric mixing; *15744*.

A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; ultrasound; velocity; absorption; acoustic; *SP453*.

A-scan; attenuation; computer analysis; impedance; liver cirrhosis; ultrasonics; *SP453*, pp. 61-70 (Oct. 1976).

A-scan; digitization; pattern recognition; speech spectrogram; ultrasound; analog-digital converter; *SP453*, pp. 51-59 (Oct. 1976).

A-scan analysis; digital; grey-scale ultrasound; spleen; splenomegaly; *SP453*, pp. 71-78 (Oct. 1976).

Ashing; blood lead; contamination; dairy products; digestion; interferences; losses; mercury; trace metal; analysis; *SP422*, pp. 661-668 (Aug. 1976).

Ashing techniques; dissolution; dry ashing; organic materials analysis; trace element analysis; wet ashing; *SP422*, pp. 491-507 (Aug. 1976).

Ashing (wet and dry); chemical errors; contamination; dissolution techniques; fusion dissolution; radiochemical analyses; *SP422*, pp. 463-490 (Aug. 1976).

ASHRAE; buildings; computer; energy calculation; heat transfer; heating and cooling loads; response factor; algorithm; *16630*.

ASHRAE task group on energy requirements; conduction transfer functions; heating and cooling load; National Bureau of Standards heating and cooling load computer program; *BSS69.*

Askarel; capacitors; insulating fluids; liquid insulators; polychlorinated biphenyls; transformers; *NBSIR 76-1054.*

Asphalt; built-up roofing; interply thickness; roofing membranes; viscosity; application temperature; *BSS92.*

Assemblage; design critiques; feedback; teaching method; architectural-design teaching; *16020.*

Assistance; certification programs; education of metrologists; industrializing nations; LDC's; metrology; AID; *NBSIR 76-988.*

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ASTM-type reference standards; calibration; interim reference standard; longitudinal beam; measurement system; nondestructive evaluation; pulse-echo; ultrasonics; aluminum ultrasonic reference standards; *TN924.*

ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; metallurgical variables; nondestructive evaluation; pulse echo; steel ultrasonic standards; titanium ultrasonic standards; ultrasonics; *NBSIR 76-984.*

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Atmospheric chemistry; chemical kinetics; data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant; *16067.*

Atmospheric contamination; blank value; indophenol blue reaction; Kjeldahl digestion technique; limit of detection; nitrogen in steel; *SP422,* pp. 983-1003 (Aug. 1976).

Atmospheric mixing; atmospheric radioactivity; cosmic ray reactions; isotopic enrichment; ^{37}Ar; *16388.*

Atmospheric mixing; blank corrections; cosmic ray reactions; effectively zero background; environmental radioactivity; low-level counting statistics; radioactive rare gases; reduced activity; argon-37; *16345.*

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Atmospheric radioactivity; cosmic-ray reactions; exponential distribution; low-level counting; noble gas separation; on-line computer; pulse shape discrimination; tropospheric mixing; Ar-37; *15744.*

Atmospheric radioactivity; cosmic ray reactions; isotopic enrichment; ^{37}Ar; atmospheric mixing; *16388.*

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Atom; collision cross section; detachment; dissociation; elastic scattering; electron; excitation; fluorescence; ion; ionization; molecule; photon; positron; *SP426.*

Atom; collisions; electron; low energy; review; scattering; theory; *15883.*

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Atomic absorption; atomic spectrometry; background, correction; nonflame, atomization; stray light; xenon-mercury, arc lamp; arsenic; *15894.*

Atomic absorption; background correction; Delves Cup; lead; spectrophotometry; *SP422,* pp. 1035-1043 (Aug. 1976).

Atomic absorption; bluegills; cadmium; fish; heavy metal; tissue; trace element analysis; water pollution; *SP422,* pp. 1063-1072 (Aug. 1976).

Atomic absorption; cadmium; copper; lead; manganese; sensitivity; spectrophotometry; statistical methods; zinc; *SP422,* pp. 1023-1033 (Aug. 1976).

Atomic absorption; clean room; fish; mini-computer; sample preparation; toxic metals; trace determination; aquatic insects; *SP422,* pp. 627-632 (Aug. 1976).

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Break-even analysis; conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics; automobile; *SP403.*

Break-even analysis; economics; energy; industrial; *SP403,* pp. 77-93 (June 1976).

Breaking load, rope; cable, aramid-fiber; end fittings, rope; fatigue damage; rope, aramid-fiber; slings, cargo; terminations, rope; weathering, simulated; aramid fiber rope; *NBSIR 76-1159.*

Breast; reflection techniques; ultrasound; velocity; attenuation; *SP453,* pp. 135-139 (Oct. 1976).

Breast tissue; broadband; high resolution; imaging; large aperture; pathology; pellicle; phase-contrast; transmission; ultrasound; velocity; attenuation; *SP453,* pp. 121-133 (Oct. 1976).

Breast tumor; computerized tomography; heart; reconstruction; refractive index; synthetic focus; tissues; ultrasound; acoustic attenuation; acoustic velocity; *SP453,* pp. 109-119 (Oct. 1976).

Breathing apparatus; closed loop breathing apparatus; equipment design; fire fighters; fire fighting; fire fighting equipment; fire gases; open loop breathing apparatus; protective clothing; smoke inhalation; standards; *NBS-GCR-73-10.*

Brick; buckling; composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; *BSS73.*

Bridge; deep-sea thermometer; high pressure; oceanographic thermometer; platinum resistance thermometer; pressure; pressure intensifier; pressure seal; pressure vessel; resistance; resistance thermometer; test; thermometer; thermometer leads; thermostated bath; vacuum; *TN894.*

Bridge; design; field data; gust response; model; specifications; structure; theory; wind; *SP444,* pp. I-1—I-20 (Apr. 1976).

Bridge; gust; meteorological data; topographical model; wind load; wind profile; wind tunnel; *SP444,* pp. II-1—II-20 (Apr. 1976).

Bridge decks; chloride ions; corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars; *16189.*

Bridges; buildings; codes; disaster; dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; wind; *SP444.*

Bridges; platinum thermometers; resistance measurements; thermometry; two-stage transformers; ac bridges; *16404.*

Brittle fracture; economics of failure prevention; fatigue failure; mechanical failure; mechanical reliability; stress corrosion cracking; *SP423.*

Brittle fracture; gas main pipe; welded steel pipe; *NBSIR 73-299.*

Brittle fracture; gas main pipe; impact; low carbon steel; stress corrosion cracking; *NBSIR 74-625.*

Brittle solids; ceramic surfaces; crack; degradation; fracture; Hertzian; indentation; strength; *15856.*

Brittle solids; chipping; fracture; indentation; residual stress; stress analysis; *16306.*

Brittle surfaces; chipping fracture; hardness; wear rate; abrasion; *16335.*

Broad frequency; equations; network analyzers; open circuit reflection coefficient; short circuit; standards; automatic; *16510.*

Broadband; high resolution; imaging; large aperture; pathology; pellicle; phase-contrast; transmission; ultrasound; velocity; attenuation; breast tissue; *SP453,* pp. 121-133 (Oct. 1976).

Broadband antenna; electromagnetic compatibility; fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe; *16210.*

Broadband interactive terminals; cable television uses; checkless society; computer/communications networks; computer/communications services; computer/communications standards; interactive cable television; nonentertainment television; two-way television; *NBS-GCR-75-44.*

Broadband measurements; microwave measurements; microwave power measurements; one-port parameters; six-port junction; application of six-port junction concept; automated measurements; *16501.*

Broadband signal generator; impulse bandwidth; receiver bandwidth calibration; rf burst generator; spectral intensity; *NBSIR 74-371.*

Broadbeam antennas; planar near field measurements; *16470.*

Broadcast; communication; frequency; ratio; synchronization; time; *16496.*

Broadcast of standard frequencies; frequency calibration; high frequency; low frequency; standard frequencies; television color subcarrier; time calibration; time signals; *SP432.*

Bromine; bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; fabric flammability; flame retardant mechanisms; flame retardant monomers; flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; *NBS-GCR-ETIP 76-22.*

Bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; fabric flammability; flame retardant mechanisms; flame retardant monomers; flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; *NBS-GCR-ETIP 76-22.*

B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; ultrasound; velocity; absorption; acoustic; A-scan; attenuation; *SP453.*

B-stars; C IV; O-stars; Si IV; spectra; stellar; ultraviolet; absorption; *16271.*

β-tricalcium; calcification; calcium; dicalcium phosphate; octacalcium phosphate; pyrolysis; pyrophosphate; stoichiometry; whitlockite; *15996.*

Buckling; composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; brick; *BSS73.*

Bugging; eavesdropping; electronic surveillance; microphones; receiver; tape recorder; telephone; transmitter; wiretapping; body worn antenna; *16237.*

Building; codes; concrete; construction; falsework; formwork; loads; reshoring; safety; shoring; standards; *BSS80.*

Building; construction; design; information; information retrieval system; architectural indexing systems; architecture; *NBSIR 76-1064.*

Building; energy; legislation; regulations; state; authority; *NBSIR 76-986.*

Building; estimating; fire; furniture; hazard; interior finish; smoke; *16123.*

Building acoustics; impact noise; noise; structural vibration; acoustics; *NBS-GCR-75-33.*

Building acoustics; sound reduction index; sound transmission loss; transmission loss; airborne sound transmission; architectural acoustics; *15708.*

Building classification; building thermal mass; building thermal performance; building thermal time constant; housing systems; industrialized housing; mass per unit area; Operation BREAKTHROUGH; U-value; *NBSIR 75-678.*

Building code; building regulations; collapse; failures; progressive collapse; specific resistance; abnormal loading; alternate path; annotated bibliography; bibliography; *BSS67.*

Building code; damage classification; extreme wind; tornado; wind loads; *SP444,* pp. I-34—I-39 (Apr. 1976).

Building code provisions; building codes; building component classification; building specifications; building standards; performance concept; *BSS90.*

Building codes; building component classification; building specifications; building standards; performance concept; building code provisions; *BSS90.*

Building codes; building laws and regulations; building materials—testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; prefabrication; zoning; *NBS-GCR-73-19.*

Building codes; building regulations; building regulatory system; standards; *NBSIR 76-1140.*

Building codes; building regulations; computer applications; computers; enforcement; evaluation; information systems; microfilm; microform; state-of-the-art study; automatic data processing; *NBS-GCR-74-26.*

Building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind engineering; wind loads; accelerations; *15871.*

Building codes; buildings; deflections; dynamic response; gust factors; structural engineering; wind loads; *SP444,* pp. IV-127—IV-144 (Apr. 1976).

Building codes; buildings; design; earthquakes; structural engineering; *SP444,* pp. IV-113—IV-126 (Apr. 1976).

Building codes; certification; compliance assurance; evaluation; inspection; manufactured building; model documents; NCSBCS; standards; state regulation; *BSS87.*

Building codes; cities; health and safety; historic preservation; states; *TN918.*

Building codes; column (supports); frames; long columns; reinforced concrete; slenderness ratio; strength; structural analysis; structural design; ultimate strength; bending moments; *16412.*

Building codes; computer model; decision theory; networks; specifications; standards; system engineering; *NBS-GCR-76-55.*

Building codes; computer program; decision theory; networks; specifications; standards; systems engineering; *NBS-GCR-76-56.*

Building codes; computer program; decision theory; FORTRAN; logic design; networks; specifications; standards; systems engineering; *NBS-GCR-76-57.*

Building codes; computer tapes; energy; fire; helmets; mobile homes; phase diagrams; tire pressure; air; *DIM/NBS* **60,** No. 12, 1-24 (1976).

Building codes; construction practices; damage; earthquake; houses; residential dwelling; *SP444,* pp. V-63—V-65 (Apr. 1976).

Building codes; design criteria; explosions; gas; hazardous materials; loads; progressive collapse; sonic boom; vehicular collision; bombs; *BSS89.*

Building codes; design standards; masonry construction; roofs; siding; structural engineering; wind; wind damage; wind engineering; *TN909.*

Building codes; door assemblies; performance requirements; physical security; standards; *16142.*

Building codes; factory-built housing; industrialized building; inspection; manufactured building; model codes; model documents; NCSBCS; on-site construction; prefabricated construction; standards; state-local relationship; state regulations; *NBS-GCR-74-27.*

Building codes; industrialization; less-developed country; SASO; Saudi Arabia; standardization; tentative standards; *NBSIR 75-976.*

Building collapse; corrosion; energy; environmental; frequency standards; hearing aids; high-rise buildings; metals; radiation safety; standards laboratory; synchrotron; *DIM/NBS* **60,** No. 5, 1-24 (1976).

Building component classification; building specifications; building standards; performance concept; building code provisions; building codes; *BSS90.*

Building construction; building design; building materials; building research; environmental protection; international cooperation; international standards; materials conservation; materials science; performance concept; *16027.*

Building construction; charring; combustion; fire endurance; fire test; flame emissivity; heat transfer; pyrolysis; radiant heat; thermal inertia; ASTM Standard E119; *NBS-GCR-75-50.*

Building design; building materials; building research; environmental protection; international cooperation; international standards; materials conservation; materials science; performance concept; building construction; *16027.*

Building design; consumer protection; fire control; fire detection; fire research; fire spread; flammability; *SP416, 1976 Edition.*

Building design; energy conservation; fenestration; HVAC systems; illumination; insulation; lighting; performance standard; thermal performance; ventilation; water heating; air leakage; *NBSIR 74-452.*

Building economics; building materials; economic analysis; housing; lead-based paint; lead poisoning; abatement; *TN922.*

Building elements and materials; degradation factors; durability; property measurement test; standard test methods; aging test; *NBSIR 75-955.*

Building fires; case studies; critical events; decisions; episodes; fires; home for the aged; hospital fires; human behavior; institutions; mapping; models; nursing homes; realms; *NBS-GCR-76-73.*

Building fires; construction materials; fire departments; fire detection system; fire tests; flame detectors; flammability tests; hazard analysis; interior furnishings; toxicity; bibliographies; *NBSIR 76-1120.*

Building heat transfer; computer programs; dynamic thermal performance; heat flow analysis; heating and cooling loads; thermal analysis; transient heat flows; *15762.*

Building industry; calibration system; centigrade/celsius; computer; electrical industries; environments; glass standards; government intervention; heating/cooling; lead-paint; metric; pressure transducers; thermal comforts; *DIM/NBS* **60,** No. 10, 1-24 (1976).

Building laws and regulations; building materials—testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; prefabrication; zoning; building codes; *NBS-GCR-73-19.*

Building materials; building research; environmental protection; international cooperation; international standards; materials conservation; materials science; performance concept; building construction; building design; *16027.*

Building materials; calorimetry; combustibility; flammability; heat release rate; potential heat; self heating; *16111.*

Building materials; children; housing; lead-based paint; lead poisoning; paint removal; abatement; barrier materials; *NBSIR 75-974.*

Building materials; economic analysis; housing; lead-based paint; lead poisoning; abatement; building economics; *TN922.*

Building materials; fires; optical density; room furnishings; smoke production; smoke tests; *16557.*

Building materials—testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; prefabrication; zoning; building codes; building laws and regulations; *NBS-GCR-73-19.*

Building regulations; building regulatory system; standards; building codes; *NBSIR 76-1140.*

Building regulations; collapse; failures; progressive collapse; specific resistance; abnormal loading; alternate path; annotated bibliography; bibliography; building code; *BSS67.*

Building regulations; computer applications; computers; enforcement; evaluation; information systems; microfilm; microform; state-of-the-art study; automatic data processing; building codes; *NBS-GCR-74-26.*

Building regulations; design process; European; progressive collapse; regulatory process; abnormal loading; *NBS-GCR-75-48.*

Building regulations; dimensional coordination; metric conversion; planning and scheduling; *16556.*

Building regulations; dimensional coordination; metric conversion; planning and scheduling; *TN915.*

Building regulatory system; standards; building codes; building regulations; *NBSIR 76-1140.*

Building research; building safety; perception; stair safety research; architectural psychology; architectural research; *NBSIR 76-1046.*

Building research; building technology; codes; criteria; project summaries; standards; technical bases; *SP446.*

Building research; cooperative programs; information exchange; international building research; international organization memberships; special foreign currency programs; *NBSIR 76-1162.*

Building research; criteria; energy; engineering; industry construction; measurement techniques; standards; *SP439.*

Building research; environmental protection; international cooperation; international standards; materials conservation; materials science; performance concept; building construction; building design; building materials; *16027.*

Building safety; floor surface friction; occupancy safety; slip-resistance; slip-resistance testers; walking friction; *TN895.*

Building safety; perception; stair safety research; architectural psychology; architectural research; building research; *NBSIR 76-1046.*

Building specifications; building standards; performance concept; building code provisions; building codes; building component classification; *BSS90.*

Building standards; performance concept; building code provisions; building codes; building component classification; building specifications; *BSS90.*

Building systems; industrialized housing; mobile homes; modular construction; prefabrication; zoning; building codes; building laws and regulations; building materials—testing and evaluation; *NBS-GCR-73-19.*

Building technology; codes; criteria; project summaries; standards; technical bases; building research; *SP446.*

Building technology; information handling; measurement services; Philippines; standardization; testing facilities; *NBSIR 76-1083.*

Building thermal mass; building thermal performance; building thermal time constant; housing systems; industrialized housing; mass per unit area; Operation BREAKTHROUGH; U-value; building classification; *NBSIR 75-678.*

Building thermal performance; building thermal time constant; housing systems; industrialized housing; mass per unit area; Operation BREAKTHROUGH; U-value; building classification; building thermal mass; *NBSIR 75-678.*

Building thermal time constant; housing systems; industrialized housing; mass per unit area; Operation BREAKTHROUGH; U-value; building classification; building thermal mass; building thermal performance; *NBSIR 75-678.*

Building ventilation rates; sulfur hexafluoride tracer; air infiltration instrumentation; air infiltration measurement; *TN898.*

Buildings; codes; disaster; dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; wind; bridges; *SP444.*

Buildings; codes and standards; wind loads; wind tunnels; aerodynamics; boundary layers; *SP444,* pp. II-21—II-51 (Apr. 1976).

Buildings; codes and standards; housing; hurricanes; low-rise buildings; natural disaster; structural connections; typhoons; wind loads; *NBSIR 75-790.*

Buildings; computer; energy calculation; heat transfer; heating and cooling loads; response factor; algorithm; ASHRAE; *16630.*

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Buildings; cyclones; disasters; structural engineering; tides; wind; *BSS86.*

Buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornadoes, wind; *SP444,* pp. V-35—V-49 (Apr. 1976).

Buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; *NBS-GCR-75-36.*

Buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; *NBS-GCR-75-37.*

Buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; *NBS-GCR-75-38.*

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Buildings; design; earthquakes; structural engineering; building codes; *SP444,* pp. IV-113—IV-126 (Apr. 1976).

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Buildings; energy conservation; heat transfer; *16446.*

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Buildings; fires; loads; safety; surveys; *16087.*

Buildings; solar energy; standards; *NBSIR 76-1143.*

Buildings (codes); excavation; foundations; geotechnical engineering; standards; *16535.*

Buildings (codes); failure; probability distribution functions; reliability; structural engineering; wind (meteorology); wind pressure; *16544.*

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Buildings energy; energy conservation; NBS programs; *16120.*

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Built-up roofing; interply thickness; roofing membranes; viscosity; application temperature; asphalt; *BSS92.*

Bulk; electron mean free path; exchange and correlation; jellium; *15843.*

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Bulk absorption coefficients; Fourier amplitudes; gas pressure; heat transfer; phase shifts; photoacoustic; surface absorption coefficients; transparent materials; *16558.*

Bulk damage; focal spot diameter; inclusion damage; interference ripples; pulsed DF laser damage; sapphire; scattering; waveform distortion; alkali-halides; alkaline-earth fluorides; *SP462,* pp. 136-144 (Dec. 1976).

Bulk damage; longitudinal mode control; pulsed 10.6 μm laser damage; RAP materials; transmitted pulse cutoff; variable pulse duration; alkali halides; *SP435,* pp. 118-125 (Apr. 1976).

Bulk excitons; electron loss spectroscopy; ionic crystals; Madelung potential; Mg^{+}; Mg^{2+}; MgO; Stark spectrum; surface excitons; *SP455,* pp. 59-65 (Nov. 1976).

Bulk modulus; composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; shear modulus; Young's modulus; *16264.*

Bulk modulus; compressibility; copper; copper alloys; elastic constants; Poisson ratio; pulse-echo method; resonance method; shear modulus; sound velocity; Young's modulus; *16505.*

Bulk modulus; compressibility; Debye temperature; elastic constants; plutonium; plutonium alloy; Poisson ratio; shear modulus; sound velocity; Young modulus; *16635.*

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Bulk resistivity; collector resistivity; four-probe; planar test structure; resistivity; semiconductor characterization; semiconductor device; silicon; square array; *16424.*

Bulk viscosity; density expansion; methane; modified Enskog theory; molecular correlations; nitrogen; sound absorption; argon; *16483.*

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Buoyancy; channels; film boiling; forced convection; helium I; helium II; mixed convection; nucleate boiling; subcritical; supercritical; transition; turbulent flow; *TN675.*

Buoyant flows; geophysical fluid flows; inertial waves; internal waves; rotating fluids; stratified fluids; waves in fluids; *J. Res.* **80B** No. 3, 353-402 (1976).

Burglar alarm; intrusion alarm; intrusion detector; sound sensing; standard; alarm; audio alarm; *16367.*

Burglary; consultants; crimes of opportunity; directory, (security); investigations; law enforcement; resources; security; shoplifting; theft; *16369.*

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Burns; fabric fires; FFACTS; garments; ignition sources; space heaters; *NBSIR 76-1014.*

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Cable assembly; coaxial cable; insertion loss; mobile antenna; mobile transceiver; transmission; *16294*.

Cable television uses; checkless society; computer/communications networks; computer/communications services; computer/communications standards; interactive cable television; nonentertainment television; two-way television; wired city; wired nation; *NBS-GCR-75-44*.

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Cadmium; copper; electrochemical analysis; heavy metals; lead; seawater analysis; speciation; stability of water samples; zinc; Adriatic Sea; *SP422*, pp. 917-928 (Aug. 1976).

Cadmium; environmental Standard Reference Materials; isotope dilution; lead; molybdenum; rubidium; strontium; trace analyses; *16221*.

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Cadmium telluride; gallium arsenide; germanium; laser flash method; laser windows; thermal diffusivity; *SP435*, pp. 98-106 (Apr. 1976).

Cadmium telluride; growth kinetics; mechanical properties; microstructure; stoichiometry; transmission electron microscopy; vapor deposition; *SP462*, pp. 100-118 (Dec. 1976).

CaF_2; crack coalescence; flaw detection; flaw distribution; forging; grain boundary mobility; subgrains; *SP462*, pp. 69-81 (Dec. 1976).

CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; thermal coefficient of refractive index; thermal expansion coefficient; ZnSe; BaF_2; *SP462*, pp. 58-63 (Dec. 1976).

CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; refractive index; thermal coefficient of refractive index; thermal expansion coefficient; ZnSe; BaF_2; *NBSIR 76-1115*.

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Calcium fluoride; defect pairs; equilibria; model; point defects; annealing; *15820*.

Calcium fluoride; refractive index; temperature coefficient of refractive index; *SP462*, pp. 64-68 (Dec. 1976).

Calcium hydroxide; crystal growth; crystals, electrochemical; electrolysis; solution; *16302*.

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Calculation; dosimetry; nuclear medicine; radionuclide; radiopharmaceutical; absorbed dose; *15977*.

Calculations; hydrocarbon crystals; internal friction; molecular defects; pair potentials; site model; *16074*.

Calculator; calibration; crossbar switch; low-level voltage measurements; MIDAS; programmable desk calculator; standard cell comparator; automated; *15906*.

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Calibration; cavity chamber; graphite chamber; ionization chamber; absorbed dose; *SP456*, pp. 37-39 (Nov. 1976).

Calibration; ceramic; condenser; electret; humidity; microphones; reciprocity; sensitivity; temperature; *NBSIR 76-1090*.

Calibration; communication; consumers; grain moisture measurement; laws and regulations; measurement; metric; packaging and labeling; police radar equipment; standards; supermarket automation; weights and measures; *SP442*.

Calibration; comparator; gage blocks; length; measurement process; *NBSIR 76-979*.

Calibration; complete closure design; indexing table; least squares estimation; partial closure design; standard deviation; subdivision; variance-covariance matrix; angle standard; autocollimator; *NBSIR 75-750*.

Calibration; computer; recordkeeping; x ray; automation; *SP456*, pp. 53-57 (Nov. 1976).

Calibration; constant deviation prism; geometrical model; optical square; pentaprism; reflection; refraction; standard deviation; uncertainty; autocollimator; *NBSIR 76-993*.

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Calibration; diameter; gravitational bending; interferometry; least squares line; linear model; optical flat; profile; standard deviation; uncertainty; *NBSIR 75-975*.

Calibration; dosimetry; ionization chamber; secondary standardization; *SP456*, pp. 65-69 (Nov. 1976).
Calibration; dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer; *TN914*.
Calibration; dynamic; electronic flash; photographic flashbulb; pressure; pressure measurement; pressure transducer; thermal transient; transducer; zero shift; *TN905*.
Calibration; dynamic; electronic flash; photoflash bulb; pressure; pressure measurement; pressure transducer; pressure transducer response; response; thermal transient; transducer; zero shift; *NBSIR 76-1038*.
Calibration; dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; pressure transducer; sinusoidal; space shuttle; transducer; bias pressure; *TN927*.
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Calibration; environmental gamma-rays; field testing; instruments; source distributions; *SP456*, pp. 233-248 (Nov. 1976).
Calibration; errors in spectrophotometry; interferences; multiple reflections; photometric linearity; polarization; sample characteristics; straylight; wavelength accuracy; bandwidth; *J. Res.* **80A** No. 4, 609-624 (1976).
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Calorimeter; calorimetric comparisons; electron beams; absorbed dose; *NBSIR 76-1023*.
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Carbon dioxide; cross section; electrons; excitation; infrared; rate coefficient; *16256.*

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Chemical reactions; chlorine molecules; classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; trajectories; transition-state theory; *16627.*

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Chemical reactions; collision theory; hydrogen atoms; hydrogen molecules; indistinguishable particles; nuclear spin; rate coefficients; transition-state theory; *16214.*

Chemical reactions; collision theory; cross sections; dissociation; hot atoms; isotope effects; kinetics; molecular beams; quantum mechanics; rate coefficients; recombinations; scattering theory; *16591.*

Chemical shift; fluoroalkanes; molecular dynamics; NMR; relaxation; *16327.*

Chemical shift tensor; methylene; NMR; ^{13}C; alkane; *16041.*

Chemical shifts; cis and trans isomers; peptides; proline; ring conformation; substituent effects; amides; carbon-13 magnetic resonance; *16235*.

Chemical structure; hydroperoxyl; microwave; *15849*.

Chemical thermodynamics; door security; Elliot Richardson; energy conservation; engineering; fashion; flammability; laser measurement; science; air conditioners; attic fans; basic research; *DIM/NBS* **60,** No. 6, 1-24 (1976).

Chemical vapor deposited ZnSe; elastic compliance; elastic constants; polycrystalline ZnSe; refractive index; stress-optic constants; temperature coefficient of index; thermal expansion; ZnSe; *15938*.

Chemiluminescence; electronic states; gas kinetics; laser enhanced reactions; O_3; PbO; *J. Res.* **80A** No. 2, 167-171 (1976).

Chemiluminescent; diatomic molecules; dissociation energies; high temperature; PbO; thermophysical measurements; *NBSIR 75-751*.

Chemisorption; cluster states; electronic structure; energy bands; perovskites; surface states; transition metal oxides; catalysis; *SP455*, pp. 21-52 (Nov. 1976).

Chemisorption; CO; cyclotron resonance; electron cyclotron resonance; magnetic field; microwave discharge; photoemission; tungsten; ultraviolet photoemission; adsorption; *16016*.

Chemisorption; corrosion preventives; inhibitor additives; LOX compatible greases; nonreactive lubricants; rust inhibited perfluoro greases; surface chemistry lubrication; *SP452*, pp. 106-119 (Sept. 1976).

Chemisorption; cus; heterogeneous catalysis; surface coordinative unsaturation; catalytic hydrogenation; catalytic oxidation; *SP455*, pp. 155-166 (Nov. 1976).

Chemisorption; cyclic-voltammetry; electrochemical adsorption; monolayers; surface processes; atomic layers; *SP455*, pp. 107-124 (Nov. 1976).

Chemisorption; density dependent transitions; desorption; dissociative adsorption; electronic states; hydrogen; monolayers; nitrogen; oxygen; photoelectron spectra; relaxation energy; surfaces; tungsten; ultraviolet photoemission; valence band; virgin states; α states; *16419*.

Chemisorption; desorption; photoelectron spectroscopy; photoemission; single crystal; tungsten; ultraviolet photoelectron spectroscopy; virgin CO; adsorption; carbon monoxide; *15851*.

Chemisorption; electrocatalysis; electrochemistry; electrode processes; nonmetals; photoelectrolysis; solid electrolytes; surfaces; catalysis; characterization; *SP455*.

Chemisorption; electrocatalysis; electron transfer theory; multistep redox reactions; semiconductor surface states; *SP455*, pp. 1-19 (Nov. 1976).

Chemisorption; electron spectroscopy; photoemission; angular distributions; *15759*.

Chemisorption; electron stimulated desorption; ion angular distribution; oxygen; tungsten; carbon monoxide; *16398*.

Chemisorption; electronic properties of solids; molecules; surfaces; adsorption; *15758*.

Chemisorption; ESCA; extra-atomic relaxation; formaldehyde; oxygen; photoelectron spectroscopy; physisorption; tungsten; xenon; XPS; carbon monoxide; *16023*.

Chemisorption; ESCA; field emission; photoemission; surfaces; x-ray photoemission; *16454*.

Chemisorption; formaldehyde; oxygen; physisorption; surface chemistry; tungsten; x-ray photoelectron spectroscopy; carbon dioxide; carbon monoxide; *16085*.

Chemisorption; photoemission; relaxation energy; surface plasmons; *15857*.

Chemisorption; ruthenium; ultraviolet photoelectron spectroscopy; x-ray photoelectron spectroscopy; adsorbate; *15814*.

Chemisorption theory; metal clusters; molecular orbitals; quantum chemistry; transition metal complexes; catalysis; *SP455*, pp. 67-86 (Nov. 1976).

Chemistry; composite resins; dental materials; hydroxybenzoic acids; pit and fissure sealants; preventive dental materials; acrylic resins; *15939*.

Chemistry; computer graphics; geochemistry; medicine; pattern recognition; trace elements; air particulates; blood; *SP422*, pp. 151-162 (Aug. 1976).

Chemistry; dioxide; heterogeneous; manganese; organic; oxidation; active; *15902*.

Chemorheology; degradation; elasticity; finite deformation; incompressible materials; permanent set; polymers; rubbers, viscoelasticity; anisotropy; *16339*.

Chesapeake Bay; elemental sulfur; flameless atomic absorption; petroleum; plankton; sediments; total mercury; water; *15874*.

Chevron; garnet; large-scale-integration (LSI); line width; lithography; magnetic bubble device (MB); memory storage density; N-channel metal-oxide-semiconductor (N-MOS); random-access-memory (RAM); silicon; cells; charge-coupled device (CCD); *16647*.

Child protection; closure testing; containers; medicine bottles; poison packaging; bottle caps; *NBSIR 75-722*.

Children; housing; lead paint; lead poisoning; surveys; blood; blood lead; *NBSIR 76-1024*.

Children; housing; lead-based paint; lead poisoning; paint removal; abatement; barrier materials; building materials; *NBSIR 75-974*.

Chip detectors; ferrograph; lube oil analysis; magnetic drain plugs; oil filters; oil monitors; particle detectors; spectrograph; *NBS-GCR-74-23*.

Chipping; fracture; indentation; residual stress; stress analysis; brittle solids; *16306*.

Chipping fracture; hardness; wear rate; abrasion; brittle surfaces; *16335*.

Chi-square test; precision; precision of analytical method; ultratrace level; accuracy; analysis of precision; *a priori* error; *a priori* precision; *a posteriori* precision; *SP422*, pp. 127-139 (Aug. 1976).

Chloride; crevice corrosion; ellipsometry; iron; molybdenum; repassivation kinetics; stress corrosion; chemical breakdown of passivity; *NBSIR 75-916*.

Chloride ion; corrosion; ferrous alloys; localized corrosion; passivity; chemical breakdown; *16018*.

Chloride ions; corrosion; deicing salts; epoxy coatings; organic coatings; steel reinforcing bars; bridge decks; *16189*.

Chlorinated biphenyl; chlorinated naphthalene; electric field measurement; electro-optic; high voltage measurement; Kerr coefficients; Kerr effect; space charge; Aroclor; *16384*.

Chlorinated naphthalene; electric field measurement; electro-optic; high voltage measurement; Kerr coefficients; Kerr effect; space charge; Aroclor; chlorinated biphenyl; *16384*.

Chlorine; helium; hydrogen; lithium; magnesium; nitrogen; oxygen potassium; sodium; aluminum; argon; atomic transition probabilities; beryllium; boron; carbon; *16164*.

Chlorine atoms; kinetics; ozone; resonance fluorescence; stratosphere; *15949*.

Chlorine concentration; chlorine monitor; electrochemical calibration; internal calibration; iodine detection; potassium iodide; calibration cell; *U.S. Patent 3,966,413*.

Chlorine effect; counting corrections; gamma intensity attenuation; neutron flux depression; organic liquid sample irradiation; palladium distribution ratios; platinum distribution ratios; *SP422*, pp. 1181-1187 (Aug. 1976).

Chlorine isotope; isotope separation; laser-induced reaction; laser irradiation; photochemical reaction; thiophosgene; *15959*.

Chlorine molecules; classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; trajectories; transition-state theory; chemical reactions; *16627.*

Chlorine monitor; electrochemical calibration; internal calibration; iodine detection; potassium iodide; calibration cell; chlorine concentration; *U.S. Patent 3,966,413.*

Chlorine monitoring; chlorine residuals; coulometry; flux-monitor; water analysis; water pollution; amperometry; *16082.*

Chlorine nitrate; dipole moment; microwave spectrum; ozone depletion; rotational constants; stratospheric chemistry; atmospheric pollution; *16584.*

Chlorine residuals; coulometry; flux-monitor; water analysis; water pollution; amperometry; chlorine monitoring; *16082.*

Chlorofluoromethanes; ideal gas thermodynamic functions; principal moments of inertia; standard enthalpy of formation; vibrational fundamentals; *JPCRD* **5**, No. 3, 571-580 (1976).

Chondrocalcinosis; pseudogout; solubility; solubility product; synovial fluid; calcium diphosphate; calcium pyrophosphate; *16230.*

Chromatography; color matching; color measurement; diffuse reflectance; Kubelka-Munk function; reflectance; reflectance standards; thin layer chromatography; *J. Res.* **80A** No. 4, 551-565 (1976).

Chromatography; coupling of high speed plasma; gas chromatography; high speed plasma; plasma; *16340.*

Chromatography; impurities in NADH preparations; NADH stability; preparative chromatography on DEAE-cellulose; spectrophotometric properties of pure NADH; ADP; ADP-ribose; *16316.*

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Chromium; flameless atomic absorption; volatile chromium compounds; biological materials; biological standards; *SP422*, pp. 605-610 (Aug. 1976).

Chromium; stability; storage containers; adsorption losses; biological systems; *SP422*, pp. 611-619 (Aug. 1976).

Chromium carbonyl; infrared spectroscopy; metal carbonyl; molybdenum carbonyl; NMR spectroscopy; 1,3-dithiolene-2-thione; *15985.*

Chromium 3+; crystal vacancies; cubic crystals; depolarization; impurity compensation; luminescence; magnesium oxide; MgO; optical properties; polarized luminescence; symmetry; transition metal ions; *16521.*

Chromospheres; line formation; radiative transfer; stars: *16052.*

Chromospheres, stellar; *Copernicus* observations; ultraviolet stellar spectra; Wilson-Bappu effect; *15784.*

Chromosphere-sun; coronal holes; diffusion; transition region-sun; ultraviolet spectrum-sun; *15717.*

Chronograph; frequency-stability measurement; instrumentation; laboratory technique; time measurement; *TN691.*

Chrysoberyl; drop calorimetry; enthalpy measurements; high temperature calorimetry; specific heat; thermodynamic properties; beryllium aluminate; *J. Res.* **80A** No. 1, 65-73 (1976).

CH_2F_2 photolysis; fluorescence spectrum; matrix isolation; absorption spectrum; band experiment; CF_2; *15908.*

CH_4 hyperfine structure; high resolution spectroscopy; laser spectroscopy; line shape; optical frequency standards; recoil effect; relativity; *16603.*

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Circuit procurement; component screening; custom circuits; LSI; microelectronics; parameter control; process uniformity; random faults; reliability; test patterns; TTL; vendor qualification; *16620.*

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Cities; health and safety; historic preservation; states; building codes; *TN918.*

Citizen rights; computers; confidentiality; data systems; health records; information policy; management principles; medical records; privacy; recordkeeping practices; security; *Monogr. 157.*

Civilian, technological innovation; social purposes, civilian; technological innovation; *NBS-GCR-75-42.*

Clapeyron equation; saturation vapor pressure over water; steam; vapor pressure; vapor pressure of water; virial coefficients; *J. Res.* **80A** Nos. 5 and 6, 775-785 (1976).

Class; cluster; data abstraction; data type; module; programming methods; program modifications; type; abstract data types; *16246.*

Classical probability matrix theory; classical scattering matrix theory; collision theory; energy transfer in collisions; hydrogen molecules; information theory; scattering theory; trajectories; vibrational energy; chemical reactions; *16607.*

Classical scattering matrix theory; collision theory; hydrogen atoms; hydrogen molecules; scattering theory; trajectories; uniform approximation; chemical reactions; *16054.*

Classical scattering matrix theory; collision theory; scattering theory; trajectories; *16593.*

Classical scattering matrix theory; collision theory; energy transfer in collisions; hydrogen molecules; information theory; scattering theory; trajectories; vibrational energy; chemical reactions; classical probability matrix theory; *16607.*

Classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; trajectories; transition-state theory; chemical reactions; chlorine molecules; *16627.*

Classification; computer; fingerprint; identification; pattern recognition; scanner; *16030.*

Classification; containment; designation; light sources; national standard; radiation source; radioactive; radioluminous products; self-luminous sources; test procedures; *H116.*

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Clebsch-Gordon series; irreducible character; matrix functions; multiple transitivity; permutation group; Stirling numbers; bell numbers; branching theorem; *J. Res.* **80B** No. 2, 265-268 (1976).

$ClHCl^-$; emission spectrum; HAr_n^+; $HCCl_2^+$; $HCCl_2^-$; $HCCl_3$; infrared spectrum; matrix isolation; molecular rotation in solid Ar; photoinduced proton transfer; ultraviolet spectrum; Ar metastable interactions; *15757.*

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Clinical chemistry; clinical sampling; enzyme analysis; storage of clinical samples; accuracy and precision; analysis of body fluids; clinical analysis; *SP422,* pp. 353-361 (Aug. 1976).

Clinical chemistry; health; precision; accuracy; clinical analysis; *SP422,* pp. 837-850 (Aug. 1976).

Clinical chemistry; industrial lead hygiene; interlaboratory correlations; lead hygiene control; occupational exposure standard criteria; occupational health control; precision; trace element analyses; accuracy; blood lead analyses; *SP422,* pp. 275-282 (Aug. 1976).

Clinical chemistry; quality control; surrogate specimens; trace elements; accuracy and precision; *SP422,* pp. 35-40 (Aug. 1976).

Clinical control materials; clinical standards; consensus standards; reference materials; calibration reference materials; calibrators; *16358.*

Clinical instruments; instruments, clinical; temperature measurements; *16021.*

Clinical laboratory data; specimen collection; specimen handling; accuracy, precision and specificity of analytical methods; biological and genetic variability; *SP422,* pp. 109-122 (Aug. 1976).

Clinical reference method; definitive glucose method; glucose in serum; isotope dilution-mass spectrometry; serum glucose; *16343.*

Clinical sampling; enzyme analysis; storage of clinical samples; accuracy and precision; analysis of body fluids; clinical analysis; clinical chemistry; *SP422,* pp. 353-361 (Aug. 1976).

Clinical standards; consensus standards; reference materials; calibration reference materials; calibrators; clinical control materials; *16358.*

Clique; clique graph; intersection graph; pseudointersection graph; set covering; *J. Res.* **80B** No. 4, 441-445 (1976).

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Clock; microprocessor; satellite; time; time code; *TN681.*

Clock acceleration effect; definition of the second; frequency accuracy; frequency standards; general relativity; gravitational redshift; primary frequency standards; proper time; UTC; atomic clocks; *16236.*

Clocks; crystal oscillator; frequency standards; stability; survey of clocks; accuracy; atomic clocks; *15719.*

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Closed circuit television; court proceedings; court security; trial proceedings; videotape recording; *16186.*

Closed die; forging; isostatic; polishing; quartz; shaping; *SP462,* pp. 95-99 (Dec. 1976).

Closed loop breathing apparatus; equipment design; fire fighters; fire fighting; fire fighting equipment; fire gases; open loop breathing apparatus; protective clothing; smoke inhalation; standards; breathing apparatus; *NBS-GCR-73-10.*

Closure testing; containers; medicine bottles; poison packaging; bottle caps; child protection; *NBSIR 75-722.*

Clothing; firemen's turnout coats; use type tests for comfort and effectiveness; *NBS-GCR-74-25.*

Cloud seeding; frequency distribution; hurricanes; typhoon; wind; wind intensities; *SP444,* pp. I-21—I-33 (Apr. 1976).

Cluster; data abstraction; data type; module; programming methods; program modifications; type; abstract data types; class; *16246.*

Cluster states; electronic structure; energy bands; perovskites; surface states; transition metal oxides; catalysis; chemisorption; *SP455,* pp. 21-52 (Nov. 1976).

Clusters; metal-metal bonding; metal sulfides; sulfides; tungsten; x-ray crystallography; *16071.*

CO^+; CO_2^+; coincidence; electron impact; ions; lifetime; molecule; N_2^+; radiative; transition probability; *15912.*

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CO; cyclotron resonance; electron cyclotron resonance; magnetic field; microwave discharge; photoemission; tungsten; ultraviolet photoemission; adsorption; chemisorption; *16016.*

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CO laser mirrors; dielectric-enhanced mirrors; infrared laser mirrors; metal mirrors; reflectance; absorptance; CO laser calorimetry; *SP462,* pp. 189-194 (Dec. 1976).

Coal; coal mine safety; dielectric constant; energy; microwave measurement; nondestructive testing; thickness of coal layer; automation; *NBSIR 76-840.*

Coal; earthquakes; geologic faults; mining; tectonics; acoustics; *NBS-GCR-73-18.*

Coal; energy; fuel; graphite; hydrocarbons; metering; methane; natural gas; petroleum; physical properties; standard reference materials; *SP434.*

Coal; environmental samples; environmental standards; fly ash; instrumental neutron activation analysis (INAA); instrumental photon activation analysis (IPAA); natural radioactivity; standard reference materials; trace elements; *SP422,* pp. 211-223 (Aug. 1976).

Coal conversion; coal gasification; corrosion; fracture; vaporization; ceramics; *16243.*

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Coal mine safety; dielectric constant; energy; microwave mea-

surement; nondestructive testing; thickness of coal layer; automation; coal; *NBSIR 76-840.*

Coastal processes; offshore zone; oscillatory water tunnel; permeability effect on sand transport; ripples, sand; sand motion under waves; beach accretion; *15793.*

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Coating damage; laser damage; mirrors; multilayer dielectric coatings; polarizers; *SP435,* pp. 298-304 (Apr. 1976).

Coating deposition; index of refraction; laser windows; surface composition; 10.6 μm; As_2S_3; *SP435,* pp. 244-247 (Apr. 1976).

Coating design; multilayer coating; absorptance; antireflectance coating; bandwidth; *SP462,* pp. 221-229 (Dec. 1976).

Coating topography; KCl; laser window coatings; ZnS; CeF_3; CO_2 pulsed laser damage; *SP435,* pp. 236-243 (Apr. 1976).

Coatings; corrosion behavior; field tests; galvanic couples; soil environment; stainless steels; stress-corrosion behavior; *NBSIR 76-1081.*

Coatings; CVD; hot pressed; sputtered; absorption damage levels; *SP462,* pp. 253-263 (Dec. 1976).

Coatings; design charts; elastomers; erosion; Hopkinson pressure bar apparatus; impedances; mismatching; stress wave interactions; substrates; tearing; vibratory apparatus; adhesion; cavitation; *SP452,* pp. 120-123 (Sept. 1976).

Coatings; dynamic; dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift; *NBSIR 76-1144.*

Coatings; friction; metal; polymers; wear; adhesion; *SP452,* pp. 3-13 (Sept. 1976).

Coatings; KCl; laser damage; alkali halides; antireflection coatings; *SP462,* pp. 283-291 (Dec. 1976).

Coatings; laser damage; laser windows; 10.6 μm lasers; *SP462,* pp. 264-278 (Dec. 1976).

Coatings; photoflash bulb; pressure transducer; protective coatings; thermal radiant-energy response; thermal transient response; transducer; *NBSIR 76-1060.*

Coatings, metallic; metallic coatings; sliding wear; *SP452,* pp. 84-93 (Sept. 1976).

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Coaxial connectors; connectors; RF connectors; SMA connectors; *16476.*

Coaxial connectors; insertion loss; microwave; reflection coefficient magnitude; repeatability; *16495.*

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Cobalt-60; exposure standard; international intercomparison; *16095.*

Cobalt-60; ionization chamber; calorimetry; *16435.*

Cobalt-60 gamma radiation; computation check; dose interpretation; mailings; results; therapy departments; thermoluminescence dosimeters; uncertainty; water phantom; absorbed dose; *J. Res.* **80A** No. 4, 663-668 (1976).

COBOL; COBOL coding form; Federal Information Processing Standard; Federal Standard COBOL; software; standards conformance; *FIPS PUB 44.*

COBOL; Federal ADP installations; Federal Standard COBOL; impact evaluation; sample; software management; survey; ADP; *NBSIR 76-1100.*

COBOL coding form; Federal Information Processing Standard; Federal Standard COBOL; software; standards conformance; COBOL; *FIPS PUB 44.*

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Codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law; architectural glazing; *NBSIR 76-1109.*

Codes; criteria; project summaries; standards; technical bases; building research; building technology; *SP446.*

Codes; disaster; dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; wind; bridges; buildings; *SP444.*

Codes and standards; housing; hurricanes; low-rise buildings; natural disaster; structural connections; typhoons; wind loads; buildings; *NBSIR 75-790.*

Codes and standards; wind loads; wind tunnels; aerodynamics; boundary layers; buildings; *SP444,* pp. II-21—II-51 (Apr. 1976)

Coding; costs; data transmission systems; decisionmaking; economics; errors; information theory; input-output devices; interfaces; malfunctions; man-machine systems; remote control systems; systems engineering; state-of-the-art reviews; acceptability; *NBS-GCR-74-29.*

Coding; interfaces; modems; signal processing; standards; teletypewriters; *NBS-GCR-74-30.*

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Collagen; conformation; correlation times; cyanogen bromide peptides; polypeptides; relaxation times; rotational diffusion; ^{13}C magnetic resonance; *16211.*

Collapse; failures; progressive collapse; specific resistance; abnormal loading; alternate path; annotated bibliography;

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Collision; Coulomb-interaction; electron; energy exchange; ionization; threshold; atom; *15884.*

Collision chains; halogen emission; intrinsic damage; multiphoton absorption; alkali halides; *SP435,* pp. 366-368 (Apr. 1976).

Collision cross section; detachment; dissociation; elastic scattering; electron; excitation; fluorescence; ion; ionization; molecule; photon; positron; atom; *SP426.*

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Collision theory; hydrogen atoms; hydrogen molecules; indistinguishable particles; nuclear spin; rate coefficients; transition-state theory; chemical reactions; *16214.*

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Colloidal alumina and silica for dental porcelain; dental porcelain; porcelain balling reduction; ammonium stabilized silica and alumina sols; *U.S. Patent 3,973,970.*

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Color matching; color measurement; diffuse reflectance; Kubelka-Munk function; reflectance; reflectance standards; thin layer chromatography; chromatography; *J. Res.* **80A** No. 4, 551-565 (1976).

Color measurement; diffuse reflectance; Kubelka-Munk function; reflectance; reflectance standards; thin layer chromatography; chromatography; color matching; *J. Res.* **80A** No. 4, 551-565 (1976).

Color subcarrier; frequency calibration; frequency comparator; frequency measurements; oscillator calibration; phase comparison; television receiver; *U.S. Patent 3,958,269.*

Color superposition photography; field-ion microscopy; image analysis; three-color superposition; *16228.*

Color-coded B-scan; Fourier transform; spectral analysis; tissue structure; ultrasound; *SP453,* pp. 97-107 (Oct. 1976).

Colorimetry; color; *16117.*

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Combinatorial analysis; combinatorial probability; measure theory; minimax; *J. Res.* **80B** No. 2, 237-243 (1976).

Combinatorial equivalence; linear inequalities; linear programs; pivot operations; skew symmetry; *16127.*

Combinatorial probability; measure theory; minimax; combinatorial analysis; *J. Res.* **80B** No. 2, 237-243 (1976).

Combustibility; flammability; heat release rate; potential heat; self heating; building materials; calorimetry; *16111.*

Combustion; cotton fibers; flame retardant treatments; phosphorous acids; pyrolysis; ramie; rayon; sulfur; cellulosic fibers; *NBS-GCR-73-4.*

Combustion; data base; energy conservation; estimation schemes; kinetics; modeling; oxidation; pyrolysis; *NBSIR 75-910.*

Combustion; fire endurance; fire test; flame emissivity; heat transfer; pyrolysis; radiant heat; thermal inertia; ASTM Standard E119; building construction; charring; *NBS-GCR-75-50.*

Combustion; fire test; heat release; limiting thermal index; pyrolysis; radiant heat; thermal sensitivity index; calorimeter; *NBS-GCR-76-54.*

Combustion; free radicals; gas phase; hydrocarbons; oxidation; oxygen; oxygenated organic compounds; ozone; bibliography; chemical kinetics; *SP449.*

Combustion gases; fire endurance; insulation; intumescent paint; potential heat; reinforced plastic; small furnace test; smoke; aluminum bulkhead; *NBSIR 76-1012.*

Combustion models; flame spread; fluid flow; laser doppler velocimetry; liquid fuels; solid fuels; surface tension; *NBS-GCR-76-79.*

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Combustion products; fire gases; fire hazards; furniture; life hazard; oxygen; smoke; temperature; toxicity; upholstery; bedding; beds; carbon dioxide; carbon monoxide; *NBS-GCR-73-1.*

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Comet; electric-dipole transition; excited states; NH; spin-orbit coupling; transition probability; *16502*.

Comets; fluorescence; OH-18-cm radiation; optical pumping; polarization; *16513*.

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Commercial alloys; corrosion; data sources; metals; *SP396-3*.

Commercial alloys; data sources; electrical properties; magnetic properties; metals; *SP396-4*.

Commercial buildings; energy conservation; energy consumption; Manchester office building; National Bureau of Standards; New York State offices; office buildings; *16547*.

Commodity flow analysis; economic analysis; National Network Simulation system; *NBSIR 75-918*.

Commodity supply crisis; econometric analysis; economic impacts; efficiency impacts; income distribution effects; policy alternatives; applied microeconomic framework; *NBS-GCR-ETIP 76-24*.

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Common practices; communication; compatibility; convertibility; information interchange; information networks; interfacing; interlibrary communication; man-machine interaction; network protocols; *16053*.

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Communications; digital communications; guideline; law enforcement equipment report, Law Enforcement Standards Laboratory; mobile digital equipment; National Institute of Law Enforcement and Criminal Justice; *16190*.

Communications; electromagnetic compatibility; law enforcement; personal transmitter; portable transmitter; radio frequency carrier; transmitter; audiofrequency modulation; *16285*.

Communications; fixed transmitter; FM transmitter; law enforcement; transmitter; base station transmitter; *16286*.

Communications networks; computer networks; cost; interactive service; measurement; measures; performance; usability; *TN908*.

Communications technology developments; computer developments; COM systems extension; copyright protection; facsimile transmission extension; photocopying; reprography developments; bibliographic data files; *16040*.

Community noise; computer interface; instrumentation; minicomputer; noise; *NBSIR 75-692*.

Community services; cooling; electric power; energy conservation; heating; incineration; integrated utility systems; resource conservation; utilities; utility services; water reuse; *16153*.

Comparative analyses; error evaluation; geological materials; instrumental-neutron activation analysis; *SP422*, pp. 1241-1256 (Aug. 1976).

Comparator; gage blocks; length; measurement process; calibration; *NBSIR 76-979*.

Comparator; International Practical Temperature Scale of 1968; IPTS-68; oxygen point; platinum resistance thermometer; temperature standard; tin point; triple point of water; zinc point; *J. Res.* **80A** No. 3, 477-504 (1976).

Comparison between NAA and AAS; neutron activation analysis (NAA); time of analysis in NAA and AAS; trace element content in liver biopsies; trace element content in tumor bearing animals; Wilson's disease; *SP422*, pp. 231-238 (Aug. 1976).

Comparison of trace analytical methods; contamination; rocks and ores; sample preparation; trace element analysis; accuracy and precision; *SP422*, pp. 773-790 (Aug. 1976).

Compatibility; convertibility; information interchange; information networks; interfacing; interlibrary communication; man-machine interaction; network protocols; common practices; communication; *16053*.

Compatibility; electropolated soft metal film coatings; metallurgical; metals; soft metals; solid lubricants; *SP452*, pp. 72-83 (Sept. 1976).

Compilation; critical evaluation; elements; thermal expansion; alloys; coefficients of thermal expansion; *16005*.

Compiler validation; computer programming; formal language; programming language standards; ADP standards; BASIC; compilers; *NBS-GCR-73-17*.

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Complete closure design; indexing table; least squares estimation; partial closure design; standard deviation; subdivision; variance-covariance matrix; angle standard; autocollimator; calibration; *NBSIR 75-750*.

Complete elliptic integral; cubic lattice; definite integral; special functions; *J. Res.* **80B** No. 2, 313-323 (1976).

Complex equilibria; convective diffusion; evaporative rate; purification (evaporative); solutal-capillary; thermal capillary convection; vacuum vaporization; Al_2O_3; *15968*.

Complex object; laminagraphy; multiple-film; radiographic inspection; thermal neutrons; three-dimensional; *16371*.

Compliance assurance; evaluation; inspection; manufactured building; model documents; NCSBCS; standards; state regulation; building codes; certification; *BSS87*.

Compliance testing; laboratory evaluation; performance testing; qualified products lists; testing; acceptance testing; *NBSIR 75-719*.

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Composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; brick; buckling; *BSS73.*
Composites; copper alloys; cryogenic temperatures; elastic properties; engineering materials; fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity; *NBSIR 75-828.*
Composites; cryogenic temperatures; elastic properties; engineering materials; fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity; aluminum alloys; *NBSIR 76-839.*
Composites; dental; grafting; investments; polymer; resin; wear; adhesion; adsorption; alloys; *NBSIR 76-1095.*
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Composites; dental materials; fillers; porous glass; radiopacity; reinforcements; wear; composite resins; *16587.*
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Composition; critical fields; critical temperature; crystallographic data; low temperature; superconductive materials; superconductivity; bibliography; *JPCRD* **5,** No. 3, 581-822 (1976).
Composition; isotopic; lithium; potassium; relative; rocks; rubidium; soils; absolute; Apollo; *15869.*
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Compressive strength; flexural strength; fracture mechanics; polymer impregnated cement; polymer impregnated mortar; porosity; scanning electron microscopy; cement; *BSS83.*
Compressor efficiency; cycle efficiency; heat exchanger losses; hydrogen liquefier; pressure drop losses; *15879.*
Compromise; ineffectiveness; measurements; radiation; regulations; states; abstract; *SP456,* pp. 31-36 (Nov. 1976).
Computation check; dose interpretation; mailings; results; therapy departments; thermoluminescence dosimeters; uncertainty; water phantom; absorbed dose; cobalt-60 gamma radiation; *J. Res.* **80A** No. 4, 663-668 (1976).
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Computer; data processing; definitions; Federal Information Processing Standards Publication; information processing; privacy; security; terms; vocabulary; *FIPS PUB 39.*
Computer; deconvolution; impedance; impulse response; layer model; lucite; ultrasound; attenuation; *SP453,* pp. 231-251 (Oct. 1976).
Computer; electrical industries; environments; glass standards; government intervention; heating/cooling; lead-paint; metric; pressure transducers; thermal comforts; weights and measures; building industry; calibration system; *DIM/NBS* **60,** No. 10, 1-24 (1976).
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Computer age; data system; materials research; measurement challenge; science and technology; sea of data; standard reference data system; *DIM/NBS* **60/Suppl.,** Anniversary Issue, 1-32 (1976).
Computer aided manufacturing systems; computer integrated manufacturing systems; interfaces; motivation for standardization; standards; automation; *16350.*
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Computer analysis; impedance; liver cirrhosis; ultrasonics; A-scan; attenuation; *SP453,* pp. 61-70 (Oct. 1976).
Computer analysis; laser induced stresses; stress analysis; thermal analysis; zinc selenide window; *SP462,* pp. 29-35 (Dec. 1976).
Computer applications; computer engineering; distributed systems; interface standards; memory technology; protocols; automated reading technology; circuitry; *16553.*
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Computer calculations; crystal structure; epitaxy; lattice misfit; pattern recognition; twinning; *TN893.*

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Computer control; manipulators; robots; robot systems; artificial intelligence; automation; *16047.*

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Computer engineering; distributed systems; interface standards; memory technology; protocols; automated reading technology; circuitry; computer applications; *16553.*

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Computer interface; computer software for robot control; hierarchical control of manipulators; position servos; trajectory control; computer control of automation systems; *NBSIR 75-973.*

Computer interface; instrumentation; minicomputer; noise; community noise; *NBSIR 75-692.*

Computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs; *NBSIR 76-985.*

Computer model; decision theory; networks; specifications; standards; system engineering; building codes; *NBS-GCR-76-55.*

Computer modeling on a microscale; elastoplastic micropressure vessels; failure predictability through small size; microencapsulated coated fuel particles; *SP452,* pp. 31-42 (Sept. 1976).

Computer network; data communications; resource sharing; bibliography; *SP384.*

Computer networking; data communications; networks; performance requirements; telecommunications; computer communications; *16551.*

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Computer networking; load leveling; resource sharing; scheduling; *16570.*

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Computer processing; frequency-dependent attenuation; internal scattering; myocardial infarction; scattering; surface scattering; tissue characterization; ultrasonic spectroscopy; ultrasound diagnosis; acoustic impedance; Bragg diffraction; *SP453,* pp. 167-196 (Oct. 1976).

Computer program; decision theory; networks; specifications; standards; systems engineering; building codes; *NBS-GCR-76-56.*

Computer program; decision theory; FORTRAN; logic design; networks; specifications; standards; systems engineering; building codes; *NBS-GCR-76-57.*

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Computer program testing; FORTRAN programs; program analysis; software verification; automatic testing; *NBS-GCR-75-47.*

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Computer programs; data evaluation; electrolytes; electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic properties; vapor pressure; activity coefficients; aqueous; *TN928.*

Computer programs; data manipulation; digital data; mass storage; NIRA; Photonuclear Data Center; central computer; *TN903.*

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Computer simulation; energy transport; heat pulse; interatomic potential; molecular dynamics; second sound; shock wave; stress wave; temperature wave; thermal diffusivity; thermal relaxation; anharmonic crystal; *16138.*

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Computer systems; environmental; fire; glass door; lead nitrate; mercury thermometers; metric; nuclear power; police radars; solar energy; SRM's; *DIM/NBS* **60,** No. 2, 1-25 (1976).

Computer tapes; energy; fire; helmets; mobile homes; phase diagrams; tire pressure; air; building codes; *DIM/NBS* **60,** No. 12, 1-24 (1976).

Computer techniques; construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards; *NBSIR 76-1058.*

Computer technology; information storage and retrieval; interactive systems; online services; online systems; bibliographic information systems; *16548.*

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Computer-controlled measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; rotating probe devices; slotted lines; survey of automatic techniques; swept frequency measurements; Wheatstone Bridge; automatic network analyzers; *Monogr. 151.*

Computerized data analysis; data evaluation; least squares (L2); least sums (L1); thermochemistry; thermodynamic data networks; *NBSIR 76-1147.*

Computerized tomography; heart; reconstruction; refractive index; synthetic focus; tissues; ultrasound; acoustic attenuation; acoustic velocity; breast tumor; *SP453,* pp. 109-119 (Oct. 1976).

Computerized typesetting; digital plotting; graphics; Hershey character set; plotting; type fonts; typesetting; vectorized characters; alphabets; COM; *SP424.*

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Computers; data; data elements; data processing; information; information processing; International Standards; U.S. Government; American National Standards; *FIPS PUB 45.*

Computers; data base management; governments; management information systems; public services; security; standards; user groups; *15923.*

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Computers; enforcement; evaluation; information systems; microfilm; microform; state-of-the-art study; automatic data

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Concentration; detectors; extraction; gas chromatography; isolation and clean-up; mass spectrometry; organic trace analysis; qualitative accuracy; quality control; quantitative accuracy; reference materials; sampling; *SP422,* pp. 9-34 (Aug. 1976).

Concentrations; determination; dilution; electrolyte; isotope; mass spectrometry; serum; accurate; blood; *SP422,* pp. 951-960 (Aug. 1976).

Concrete; concrete-polymer systems; polymers; polymer-impregnated concrete; sulfur-impregnated concrete; *16349.*

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Concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; brick; buckling; composite walls; compressive strength; *BSS73.*

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Conduction transfer functions; heating and cooling load; National Bureau of Standards load determination procedure; computer program for buildings; *16118.*

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Conductivity; electric field effects; insulating films; insulators; metal oxidation; metals; MOM devices; oxidation; oxidation theory; parabolic law for metal oxidation; semiconductors; *16260.*

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Conservation; costs; economics; energy; thermal; *SP403,* pp. 95-101 (June 1976).

Conservation; economic; energy; management; manufacturing; *SP403,* pp. 103-111 (June 1976).

Conservation; energy; industrial; systems; attitudes; *SP403,* pp. 113-117 (June 1976).

Conservation; energy; organization; *SP403,* pp. 13-18 (June 1976).

Conservation; measurements; nondestructive evaluation; productivity; reliability; reproducibility; safety; accuracy; *16301.*

Conservation of material resources; failure prevention; government action; mechanical failure; mechanical reliability; safety standards; *SP423,* pp. 221-225 (Apr. 1976).

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Constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; standards; stiffness; structural stability; walls; brick; buckling; composite walls; compressive strength; concrete block; *BSS73.*

Constrictions; gas discharge; helium; ionized gas; numerical solutions; *16000.*

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Construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards; computer techniques; *NBSIR 76-1058.*

Construction; falsework; formwork; loads; reshoring; safety; shoring; standards; building; codes; concrete; *BSS80.*

Construction; maintenance; research accidents; safety; accidents; buildings; *16315.*

Construction materials; fire departments; fire detection system; fire tests; flame detectors; flammability tests; hazard analysis; interior furnishings; toxicity; bibliographies; building fires; *NBSIR 76-1120.*

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Construction safety; construction surety; degradation of safety with age and use; maintenance of safety; public safety; safety responsibility; *SP423,* pp. 165-170 (Apr. 1976).

Construction surety; degradation of safety with age and use; maintenance of safety; public safety; safety responsibility; construction safety; *SP423,* pp. 165-170 (Apr. 1976).

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Consumer information; efficiency; energy labeling; room air conditioners; water heaters; combination refrigerator-freezers; *15888.*

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Consumer Product Safety Act; residence-related products; residential safety modification; safety implementation approaches; architectural glass products; *16006.*

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Consumer product technology; law enforcement equipment; law enforcement equipment standards; product performance; product safety; bibliographies; consumer product safety; consumer product standards; *NBSIR 76-1066.*

Consumer products; marketing; mechanical failure; product performance; product reliability; product testing; *SP423,* pp. 209-212 (Apr. 1976).

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Consumer safety; handbrakes; testing; bicycles; braking; *NBSIR 75-953.*

Consumer safety; regulations; safety; structural testing; bicycle; *NBSIR 75-913.*

Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; state law; architectural glazing; codes; Consumer Product Safety Committee; *NBSIR 76-1109.*

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Contact lubrication; elastohydrodynamic contacts; fatigue; lubricant film thickness; scuffing; wear; *SP423,* pp. 41-54 (Apr. 1976).

Contact resistance; electrical connections; fire hazard; glowing electrical connections; arcing/sparking; branch circuit; *NBSIR 76-1011.*

Container blank; neutron activation analysis; wet-ashing blank; biological analysis; *SP422,* pp. 593-604 (Aug. 1976).

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Contamination; errors; natural water; sample storage; sampling; accuracy; analytical chemistry; *SP422,* pp. 805-836 (Aug. 1976).

Contamination; gas analysis; high purity; materials analysis; neutron activation analysis; *SP422,* pp. 759-772 (Aug. 1976).

Contamination; geological sample; rocks and minerals; sample preparation; sampling; trace analysis; water sampling; *SP422,* pp. 285-297 (Aug. 1976).

Contamination; manganese; sampling; serum; biological materials; chromium; cobalt; *SP422,* pp. 299-310 (Aug. 1976).

Contamination; rocks and ores; sample preparation; trace element analysis; accuracy and precision; comparison of trace analytical methods; *SP422,* pp. 773-790 (Aug. 1976).

Contamination control; high-purity reagents; membrane filtration; mercury cathode electrolysis; prepurification; purity definition; reagent contamination; ultrapurification; analytical blanks; analytical reagents; *SP422*, pp. 363-375 (Aug. 1976).

Contamination of atmospheric particulate samples; sample handling; shipboard atmospheric sampling; analytical blanks; atmospheric sampling; coastal sampling; *SP422*, pp. 377-388 (Aug. 1976).

Contaminations; flameless methods; lead; lead blood analyses; methodology; trace element analyses; atomic absorption spectrometry; blood analyses; *SP422*, pp. 715-719 (Aug. 1976).

Continued cotangent; continued fraction; quadratic irrational; *J. Res.* **80B** No. 2, 285-290 (1976).

Continued fraction; cosine integral; exponential integral; FORTRAN program; hyperbolic sine and cosine integrals; key values; recurrence relations; *J. Res.* **80B** No. 2, 291-313 (1976).

Continued fraction; quadratic irrational; continued cotangent; *J. Res.* **80B** No. 2, 285-290 (1976).

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Cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics; automobile; break-even analysis; conservation; *SP403*.

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Copper; electron channeling; electron microscope; metals; particle analysis; plastic deformation; surfaces; wear; wear debris; x-ray analysis; *NBSIR 76-1141*.
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Copper; molybdenum; optician; polishing; surfaces; zinc selenide; *SP435*, pp. 10-13 (Apr. 1976).
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Corrosion; environment; health care; housing production; I-R 100 awards; NIKE missile; papers available; stereology; toy safety; x-ray units; computer power; computer standard; *DIM/NBS* **60**, No. 11, 1-24 (1976).
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Data elements; data processing; information; information processing; International Standards; U.S. Government; American National Standards; computers; data; *FIPS PUB 45.*

Data entry systems; information processing systems; information processing standards; OCR; OCR forms; optical character recognition; standards; business forms; computers; *FIPS PUB 40.*

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Data evaluation; electrolytes; electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic properties; vapor pressure; activity coefficients; aqueous; computer programs; *TN928.*

Data evaluation; gas phase; hydrocarbons; ion-molecule reactions; mass spectrometry; rate coefficients; chemical kinetics; *JPCRD* **5,** No. 4, 1123-1146 (1976).

Data evaluation; gas phase; photoabsorption cross section; photochemistry; quantum yield; rate constant; atmospheric chemistry; chemical kinetics; *16067.*

Data evaluation; least squares (L2); least sums (L1); thermochemistry; thermodynamic data networks; computerized data analysis; *NBSIR 76-1147.*

Data independence; data manipulation; data model; distributed data base; generalized processing; data base; data-base machines; data-base management; data definition; data dictionary; *16330.*

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Data interpretation; standard materials; trace elements; accuracy; biological materials; *SP422,* pp. 65-77 (Aug. 1976).

Data loss, magnetic media; devices, effects on magnetic media; fields, effects on magnetic media; magnetic fields, erasure of data; magnetic media, data erasure; magnetic media, data protection; *16056.*

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Data security costs; PL-93-579; privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs; computer model; computer security; confidentiality; cost model; *NBSIR 76-985.*

Data sources; electrical properties; magnetic properties; metals; commercial alloys; *SP396-4.*

Data sources; metals; commercial alloys; corrosion; *SP396-3.*

Data system; materials research; measurement challenge; science and technology; sea of data; standard reference data

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Data systems; fabric flammability; FFACTS; fire accidents; fire data systems; fire hazards; fires; hazard analysis; NEISS; plastics flammability; product safety; accident data; *16361.*
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Decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change; *NBS-GCR-ETIP 76-04.*
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Design criteria; explosions; gas; hazardous materials; loads; progressive collapse; sonic boom; vehicular collision; bombs; building codes; *BSS89*.

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Durability; field inspection; foam and beam; honeycomb; impact; lightweight structures; military; reliability; sandwich panel; shelter; *NBSIR 76-1025*.

Durability; property measurement test; standard test methods; aging test; building elements and materials; degradation factors; *NBSIR 75-955*.

Dusts; light-scattering; Mie theory; particles; Rayleigh scattering; aerosols; *NBSIR 76-1031*.

Dye laser use for resonance fluorescence; furnace atmosphere sodium contamination; furnace qualification; resonance fluorescence; sodium trace detection; *16574*.

Dyes; glass; plastics; radiation; radiochromic dyes; spectrophotometry; colour dosimeters; dosimetry; *15960*.

Dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer; calibration; *TN914*.

Dynamic; dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift; coatings; *NBSIR 76-1144*.

Dynamic; electronic flash; photographic flashbulb; pressure; pressure measurement; pressure transducer; thermal transient; transducer; zero shift; calibration; *TN905*.

Dynamic; electronic flash; photoflash bulb; pressure; pressure measurement; pressure transducer; pressure transducer response; response; thermal transient; transducer; zero shift; calibration; *NBSIR 76-1038*.

Dynamic; floor systems; human responses; performance criteria; serviceability; static; vibration; deflection; *TN900*.

Dynamic analysis; dynamic loading; earthquake; energy dissipation; finite element; seismic response; structural engineering; analytical model; *SP444*, pp. IV-70—IV-89 (Apr. 1976).

Dynamic analysis; earthquake; seismic design; seismic response; spherical tanks; structural design; *SP444*, pp. V-50—V-62 (Apr. 1976).

Dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; wind; bridges; buildings; codes; disaster; *SP444*.

Dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornadoes, wind; buildings; damage; disaster; *SP444*, pp. V-35—V-49 (Apr. 1976).

Dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; *NBS-GCR-75-36*.

Dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; *NBS-GCR-75-37*.

Dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; *NBS-GCR-75-38.*

Dynamic analysis; errors; evaluation; program complexity; program measurement static; *16650.*

Dynamic boiler efficiency; efficiency vs cycling rate; efficiency vs heating load; gas-fired boiler; *16338.*

Dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer; calibration; dynamic; *TN914.*

Dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; pressure transducer; sinusoidal; space shuttle; transducer; bias pressure; calibration; *TN927.*

Dynamic force; economic; force; metrication; national measurement system; standards; *NBSIR 75-929.*

Dynamic loading; earthquake; energy dissipation; finite element; seismic response; structural engineering; analytical model; dynamic analysis; *SP444,* pp. IV-70—IV-89 (Apr. 1976).

Dynamic loads; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; static loads; stiffness; structural safety; design; *NBSIR 76-1131.*

Dynamic model; environmental chamber experiment; heating and cooling load computer program; heating load; masonry building; *16092.*

Dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer; calibration; dynamic; dynamic calibration; *TN914.*

Dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; pressure transducer; sinusoidal; space shuttle; transducer; bias pressure; calibration; dynamic calibration; *TN927.*

Dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; transducer; calibration; dynamic; dynamic calibration; dynamic pressure; *TN914.*

Dynamic pressure transducer; polymeric film transducer; sandwiched polymeric films; vibration transducer; *U.S. Patent 3,970,862.*

Dynamic response; gust factors; structural engineering; wind engineering; wind loads; accelerations; building codes; buildings; deflections; *15871.*

Dynamic response; gust factors; structural engineering; wind loads; building codes; buildings; deflections; *SP444,* pp. IV-127—IV-144 (Apr. 1976).

Dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift; coatings; dynamic; *NBSIR 76-1144.*

Dynamic tests; earthquake simulator; shake table; structural engineering; tests; *SP444,* pp. V-25—V-34 (Apr. 1976).

Dynamic thermal performance; heat flow analysis; heating and cooling loads; thermal analysis; transient heat flows; building heat transfer; computer programs; *15762.*

Dynamical diffraction; rocking curve; angular divergence; asymmetric diffraction; diffraction topography; *16055.*

Dynamical diffraction equation; imperfect crystals; scattering matrix theory; *15779.*

Dynamical images; immobile dislocations; Lomer locks; sessile dislocations; x-ray dynamical diffraction; x-ray topography; contrast conditions; *16373.*

Dynamics, bicycle; error analysis; friction, tire/pavement; kinetics, bicycle; measurements, bicycle braking; pitchover; standards, bicycle safety; test method, bicycle; bicycle brakes; brakes, bicycle; *NBSIR 75-786.*

Dy^{3}; paramagnetic resonance; CdF_2; *16051.*

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E^+e^- annihilation; exotic mesons; meson classification; ψ and χ particles; 1^{--} states; *15961.*

Early afterglow; electron temperature; helium metastables; helium plasma; pulse discharge; collision model; *15958.*

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Earmuffs; earplugs; gunfire noise; hearing damage; hearing protectors; law enforcement equipment; *16368.*

Earplugs; gunfire noise; hearing damage; hearing protectors; law enforcement equipment; earmuffs; *16368.*

Earth rotation; geodesy; geodynamics; geophysics; laser distance measurements; moon; *16448.*

Earth rotation; geodynamics; lunar distance; microwave interferometry; plate tectonics; satellite geodesy; crustal moments; *15799.*

Earthfill dams; earthquakes; ground shaking; liquefaction; soil density; stability; *SP444,* pp. III-24—III-37 (Apr. 1976).

Earthquake; empirical relation; Franciscan Formation; geological character; ground shaking; intensity; *SP444,* III-84—III-94 (Apr. 1976).

Earthquake; energy dissipation; finite element; seismic response; structural engineering; analytical model; dynamic analysis; dynamic loading; *SP444,* pp. IV-70—IV-89 (Apr. 1976).

Earthquake; explosion test; ground strength; ground vibration; liquefaction; pore-water pressure; *SP444,* pp. III-38—III-51 (Apr. 1976).

Earthquake; field data; ground response; seismic waves; seismometer; soil-structure interaction; *SP444,* pp. III-13—III-23 (Apr. 1976).

Earthquake; highway bridges; lateral loads; pile head; piles; structural engineering; design; *SP444,* pp. IV-90—IV-112 (Apr. 1976).

Earthquake; houses; residential dwelling; building codes; construction practices; damage; *SP444,* pp. V-63—V-65 (Apr. 1976).

Earthquake; housing; performance specification; prefabricated dwelling; standards; structural design; *SP444,* pp. IV-55—IV-69 (Apr. 1976).

Earthquake; housing; Peru; technical aid; adobe; cane; *SP444,* pp. VI-16—VI-24 (Apr. 1976).

Earthquake; Japan; natural disaster; storm; structural engineering; technological aid; *SP444,* pp. VI-25—VI-31 (Apr. 1976).

Earthquake; reinforced concrete; shear tests; structural engineering; web reinforcement; column; ductility; *SP444,* pp. IV-16—IV-36 (Apr. 1976).

Earthquake; seismic design; seismic response; spherical tanks; structural design; dynamic analysis; *SP444,* pp. V-50—V-62 (Apr. 1976).

Earthquake engineering; grant; RANN; sponsorship; structural engineering; *SP444,* pp. V-66—V-79 (Apr. 1976).

Earthquake simulator; shake table; structural engineering; tests; dynamic tests; *SP444,* pp. V-25—V-34 (Apr. 1976).

Earthquakes; falls; flows; landslides; mechanisms; slides; avalanches; *SP444,* pp. III-52—III-71 (Apr. 1976).

Earthquakes; geologic faults; mining; tectonics; acoustics; coal; *NBS-GCR-73-18.*

Earthquakes; ground shaking; liquefaction; soil density; stability; earthfill dams; *SP444*, pp. III-24—III-37 (Apr. 1976).
Earthquakes; highway bridges; retrofitting; soil-structure interaction; structural engineering; design; *SP444*, pp. V-1—V-24 (Apr. 1976).
Earthquakes; hurricanes; natural hazards; structural engineering; tornadoes, wind; buildings; damage; disaster; dynamic analysis; *SP444*, pp. V-35—V-49 (Apr. 1976).
Earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; dynamic analysis; *NBS-GCR-75-36*.
Earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; dynamic analysis; *NBS-GCR-75-37*.
Earthquakes; hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; dynamic analysis; *NBS-GCR-75-38*.
Earthquakes; low-cost housing; natural disasters; Philippines; socioeconomic aspects; typhoons; construction; design; developing countries; *NBS-GCR-73-21*.
Earthquakes; modeling; soils; structural response; volcanoes; wind; bridges; buildings; codes; disaster; dynamic analysis; *SP444*.
Earthquakes; structural engineering; building codes; buildings; design; *SP444*, pp. IV-113—IV-126 (Apr. 1976).
Ease of ignition; fabrics; fire; flammability tests; garments; heat transfer; standards; apparel; burn injury; *NBSIR 76-1072*.
Eavesdropping; electronic surveillance; microphones; receiver; tape recorder; telephone; transmitter; wiretapping; body worn antenna; bugging; *16237*.
Eccentric loading; flat-end; kern; loading rate; pin-end; test method; wall panels; walls; compression; *NBSIR 75-779*.
Econometric analysis; economic impacts; efficiency impacts; income distribution effects; policy alternatives; applied microeconomic framework; commodity supply crisis; *NBS-GCR-ETIP 76-24*.
Economic; energy; imports; international; petroleum; correlation; *SP403*, pp. 21-41 (June 1976).
Economic; energy; input-output model; *SP403*, pp. 43-56 (June 1976).
Economic; energy; management; manufacturing; conservation; *SP403*, pp. 103-111 (June 1976).
Economic; energy; model; transform analysis; automobile; *SP403*, pp. 65-74 (June 1976).
Economic; force; metrication; national measurement system; standards; dynamic force; *NBSIR 75-929*.
Economic analysis; housing; lead-based paint; lead poisoning; abatement; building economics; building materials; *TN922*.
Economic analysis; National Network Simulation system; commodity flow analysis; *NBSIR 75-918*.
Economic challenge; scientific and technical resources, converting; social opportunity; *NBS-GCR-73-3*.
Economic cost of failure prevention; frequency of failure; government action; life-cycle costing; marginal analysis; quality control; safety standards; *SP423*, pp. 107-116 (Apr. 1976).
Economic efficiency; environment; equity; financing; grants; pollution abatement; user fees; wastewater; water pollution; water resources; cost sharing; *16564*.
Economic factors; measurement; surface; surface finish; surface roughness; technology assessment; *NBSIR 75-927*.
Economic impact of automation; productivity improvement; public services; social impact of automation; automation technology; *SP448*.
Economic impacts; efficiency impacts; income distribution effects; policy alternatives; applied microeconomic framework; commodity supply crisis; econometric analysis; *NBS-GCR-ETIP 76-24*.
Economic savings of failure prevention; friction; lubrication; mechanical failure; tribology; wear; *SP423*, pp. 117-139 (Apr. 1976).
Economics; electrical quantities; ionizing radiation; mechanical quantities; national measurement system; optical quantities; surface properties; thermal quantities; time and frequency; acoustics; atomic properties; *NBSIR 75-947*.
Economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; steel; thermal; thermodynamics; automobile; break-even analysis; conservation; cooling; *SP403*.
Economics; energy; environment; costs; *SP403*, pp. 215-223 (June 1976).
Economics; energy; fuel; imports; costs; *SP403*, pp. 3-12 (June 1976).
Economics; energy; industrial; break-even analysis; *SP403*, pp. 77-93 (June 1976).
Economics; energy; thermal; conservation; costs; *SP403*, pp. 95-101 (June 1976).
Economics; errors; information theory; input-output devices; interfaces; malfunctions; man-machine systems; remote control systems; systems engineering; state-of-the-art reviews; acceptability; coding; costs; data transmission systems; decisionmaking; *NBS-GCR-74-29*.
Economics; indirect costs; subsidized costs; blood banking; cost analysis; *16070*.
Economics of failure prevention; fatigue failure; mechanical failure; mechanical reliability; stress corrosion cracking; brittle fracture; *SP423*.
Eddy currents; electron paramagnetic resonance; microwave conductivity; tetrathiofulvalinium-tetracyano-quinodimethane; TTF-TCNQ; *15917*.
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Education; International System of Units; metrication; metric education; metric system; training; Treaty of the Meter; *SP441*.
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Educational priorities; energy; engineer-scientist; environmental quality; materials; minerals; ceramics; *16156*.
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Effectively zero background; environmental radioactivity; low-level counting statistics; radioactive rare gases; reduced activity; argon-37; atmospheric mixing; blank corrections; cosmic ray reactions; *16345*.

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Efficiency; energy labeling; room air conditioners; water heaters; combination refrigerator-freezers; consumer information; *15888*.

Efficiency; environment; financing; grants; pollution abatement; wastewater; water pollution; water resources; cost sharing; *15810*.

Efficiency; fluorescent wavelength converter; photometry; spectrophotometry; ultraviolet; visible; averaging sphere; diffusing effectiveness; *16333*.

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Efficiency vs heating load; gas-fired boiler; dynamic boiler efficiency; efficiency vs cycling rate; *16338*.

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Eigenvalues; independence; quadratic form; random variable; singular value decomposition; *J. Res.* **80B** No. 3, 333-335 (1976).

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Elastic constants; elasto-optic; photoelasticity; polycrystalline ZnSe; stress optical constants; *15931*.

Elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; shear modulus; Young's modulus; bulk modulus; composite materials; *16264*.

Elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; Young's modulus; composite materials; *J. Res.* **80A** No. 1, 45-49 (1976).

Elastic constants; plutonium; plutonium alloy; Poisson ratio; shear modulus; sound velocity; Young modulus; bulk modulus; compressibility; Debye temperature; *16635*.

Elastic constants; Poisson ratio; pulse-echo method; resonance method; shear modulus; sound velocity; Young's modulus; bulk modulus; compressibility; copper; copper alloys; *16505*.

Elastic constants; polycrystalline ZnSe; refractive index; stress-optic constants; temperature coefficient of index; thermal expansion; ZnSe; chemical vapor deposited ZnSe; elastic compliance; *15938*.

Elastic medium; engineering seismology; ground layer; numerical solution; shear wave; *SP444*, pp. III-1–III-12 (Apr. 1976).

Elastic moduli; extrinsic damage thresholds; high-power lasers; infrared materials; tensile stress; cadmium telluride; elastic compliance tensor; *SP462*, pp. 119-125 (Dec. 1976).

Elastic properties; engineering materials; fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity; composites; copper alloys; cryogenic temperatures; *NBSIR 75-828*.

Elastic properties; engineering materials; fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity; aluminum alloys; composites; cryogenic temperatures; *NBSIR 76-839*.

Elastic properties; engineering materials; fatigue; fracture; iron alloys; cryogenic temperatures; maraging steels; mechanical properties; nickel alloys; phenolformaldehyde; stainless steels; superconducting machinery; thermal conductivity; titanium alloys; *NBSIR 76-848*.

Elastic scattering; electron; excitation; fluorescence; ion; ionization; molecule; photon; positron; atom; collision cross section; detachment; dissociation; *SP426*.

Elastic scattering; electron scattering; hydrogen molecules; momentum transfer; rotational excitation; scattering theory; sudden approximation; differential cross sections; *15761*.

Elastic scattering; electron scattering; momentum transfer; nitrogen molecules; rotational excitation; scattering theory; sudden approximation; close coupling calculations; cross sections; differential cross sections; *15951*.

Elastic scattering; electron scattering; exchange (of electrons); hydrogen molecules; inelastic scattering; momentum transfer; polarization (of charge clouds); rotational excitation; scattering theory; close-coupling calculations; cross sections; differential cross sections; *16532*.

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Elastohydrodynamic contacts; fatigue; lubricant film thickness; scuffing; wear; contact lubrication; *SP423*, pp. 41-54 (Apr. 1976).

Elastomers; erosion; Hopkinson pressure bar apparatus; impedances; mismatching; stress wave interactions; substrates; tearing; vibratory apparatus; adhesion; cavitation; coatings; design charts; *SP452*, pp. 120-123 (Sept. 1976).

Elasto-optic; photoelasticity; polycrystalline ZnSe; stress optical constants; elastic constants; *15931*.

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Electret; humidity; microphones; reciprocity; sensitivity; temperature; calibration; ceramic; condenser; *NBSIR 76-1090*.

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Electric energy density; energy density; near-field energy density; *16563*.

Electric field effects; insulating films; insulators; metal oxidation; metals; MOM devices; oxidation; oxidation theory; parabolic law for metal oxidation; semiconductors; conductivity; *16260*.

Electric field measurement; electro-optic; high voltage measurement; Kerr coefficients; Kerr effect; space charge; Aroclor; chlorinated biphenyl; chlorinated naphthalene; *16384*.

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Electric fields; laser damage; oblique incidence; standing waves; *SP462*, pp. 25-28 (Dec. 1976).

Electric fields; laser damage; optical coatings; standing-waves; dielectric films; *SP462*, pp. 301-309 (Dec. 1976).

Electric power; energy conservation; heating; incineration; integrated utility systems; resource conservation; utilities; utility services; water reuse; community services; cooling; *16153*.

Electric power; energy storage; generators; instrumentation; MHD; superconductivity; cryogenics; CTR; *16465*.

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Electric power industry; National Measurement System, position location; shipping and boating industries; Standards laboratories; telephone industry and specialized carriers; time and frequency; time scales; users of NBS radio broadcasts; atomic frequency standards; *SP445-1*.

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Electrical; heat conductivity; heat transfer; Lorenz function; thermal conductivity; conductivity; *15986*.

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Electrical conductivity; high temperature; MHD-power generation; spinel structure; durability; *15943*.

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Electrical measurements; electrooptics; high voltage measurement; Kerr effect; optical coupling; pulse measurement; automation; *15718*.

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Electrical properties; magnetic properties; metals; commercial alloys; data sources; *SP396-4*.

Electrical pulses; environmental standards; friction measurement; lead poisoning; LNG data; optical; standard reference materials; thermophysical properties symposium; waste heat; computer; consumer; drugs; *DIM/NBS* **60**, No. 9, 1-24 (1976).

Electrical quantities; electromagnetic quantities; end-use measurements; ionizing radiation; measurement activities; measurement institutions; mechanical quantities; National Measurement System; optical quantities; thermal quantities; time and frequency; *NBSIR 75-943*.

Electrical quantities; ionizing radiation; mechanical quantities; national measurement system; optical quantities; surface properties; thermal quantities; time and frequency; acoustics; atomic properties; economics; *NBSIR 75-947*.

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Electrocatalysis; electrochemistry; electrode processes; nonmetals; photoelectrolysis; solid electrolytes; surfaces; catalysis; characterization; chemisorption; *SP455.*

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Electrocatalysis; electronic structure; hydrogen peroxide; iron phthalocyanines; Mössbauer; optical spectra; oxygen; reaction mechanisms; ring-disk electrodes; *SP455*, pp. 241-251 (Nov. 1976).

Electrocatalysis; foreign metal monolayers; Fe^{2+}/Fe^{3+} reaction; formic acid oxidation; oxygen reduction; underpotential deposition; *SP455*, pp. 191-200 (Nov. 1976).

Electrocatalysis; fuel cells; mixed oxides; oxygen reduction; phosphoric acid; ternary metal-sulfur arrays; transition elements; triphenylphosphine; tungsten bronze; *NBSIR 75-742.*

Electrocatalysis; fuel cells; refractory hard metal; solid electrolytes; cerium dioxide; degradation; *NBSIR 76-1091.*

Electrocatalysis; heteropolyanions; phosphotungstate complex ions; "spillover" effect; transition metal carbides; transition metal oxides; tungsten bronze; tungsten carbide; *SP455*, pp. 167-174 (Nov. 1976).

Electrocatalysis; nickel oxide; oxide electrodes; oxygen electrochemistry; semiconductor electrodes; carbon; *SP455*, pp. 203-219 (Nov. 1976).

Electrocatalysis; nickel-cobalt oxide; nickel oxide; oxide electrodes; oxygen electrode reaction; ruthenium dioxide/titanium dioxide; spinel; *SP455*, pp. 289-296 (Nov. 1976).

Electrocatalysis; semiconductor electrode; tin oxide electrode; transparent electrode; adsorption; anodic oxidation; *SP455*, pp. 175-181 (Nov. 1976).

Electrocatalyst; hydrogen evolution; lanthanum titanate; oxygen electrode; photo-assisted electrolysis; rutile; *SP455*, pp. 313-321 (Nov. 1976).

Electrocatalyst; oxygen reduction; sodium depletion; Tafel plots; tungsten bronzes; Auger electron spectroscopy; *SP455*, pp. 297-303 (Nov. 1976).

Electrochemical; exchange current; semiconductor; traps; zinc oxide; dislocation; *SP455*, pp. 139-148 (Nov. 1976).

Electrochemical; lubricants; salt-spray; corrosion; *SP452*, pp. 97-105 (Sept. 1976).

Electrochemical adsorption; monolayers; surface processes; atomic layers; chemisorption; cyclic-voltammetry; *SP455*, pp. 107-124 (Nov. 1976).

Electrochemical analysis; heavy metals; lead; seawater analysis; speciation; stability of water samples; zinc; Adriatic Sea; cadmium; copper; *SP422*, pp. 917-928 (Aug. 1976).

Electrochemical analysis; twin electrode balancing; anodic stripping voltammetry; background current compensation; differential anodic stripping voltammetry; *SP422*, pp. 881-897 (Aug. 1976).

Electrochemical calibration; internal calibration; iodine detection; potassium iodide; calibration cell; chlorine concentration; chlorine monitor; *U.S. Patent 3,966,413.*

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Electrode polarization; impedance measurements; interfaces; ionic conductivity; overpotential; solid electrolyte; *15819.*

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Electrodeposition; government laboratories; plating; Blum, William; *16203.*

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Electrolyte electroreflectance; surface states; titanium dioxide; transition-metal oxides; defect states; *d*-electrons; *SP455*, pp. 125-131 (Nov. 1976).

Electrolytes; electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic proper-

ties; vapor pressure; activity coefficients; aqueous; computer programs; data evaluation; *TN928*.

Electrolytic iron; Lorenz ratio; thermal conductivity; austenitic steel; cryogenics; electrical resistivity; *16206*.

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Electromagnetic compatibility; law enforcement; personal transmitter; portable transmitter; radio frequency carrier; transmitter; audiofrequency modulation; communications; *16285*.

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Electromagnetic field synthesizer; electromagnetic radiation-exposure testing (nonionizing); near-fields; rf biological hazards; electromagnetic field hazards; *TN687*.

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Electromagnetic radiation-exposure testing (nonionizing); near-fields; rf biological hazards; electromagnetic field hazards; electromagnetic field synthesizer; *TN687*.

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Electromigration; iron; nickel; palladium; platinum; rhodium; ruthenium; thermomigration; alloys; cobalt; copper; diffusion; *JPCRD* **5**, No. 1, 103-200 (1976).

Electromotive force; isopiestic method; osmotic coefficients; nonlinear least squares; thermodynamic properties; vapor pressure; activity coefficients; aqueous; computer programs; data evaluation; electrolytes; *TN928*.

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Electron avalanche; laser-induced gas breakdown; photoionization; *SP435*, pp. 347-355 (Apr. 1976).

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Electron beam scanning; electron probe microanalysis; x-ray analysis; color composite technique; counting statistics; *15787*.

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Electron beams; absorbed dose; calorimeter; calorimetric comparisons; *NBSIR 76-1023*.

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Electron configuration; atomic energy levels; atomic spectra; atomic theory; copper; doubly ionized copper; *J. Res.* **80A** No. 3, 465-476 (1976).

Electron cyclotron resonance; magnetic field; microwave discharge; photoemission; tungsten; ultraviolet photoemission; adsorption; chemisorption; CO; cyclotron resonance; *16016*.

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Emission spectroscopy; particulate analysis; particulate characterization; sampling methods; X-ray fluorescence; atmospheric particulates; direct analysis techniques; *SP422*, pp. 791-803 (Aug. 1976).
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End-use measurements; ionizing radiation; measurement activities; measurement institutions; mechanical quantities; National Measurement System; optical quantities; thermal quantities; time and frequency; acoustic quantities; electrical quantities; *NBSIR 75-943*.
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Energy; EPIC supplement; high winds; home security; nondestructive evaluation; research associate program; school systems; smoke detectors; teaching metric; cryogenic fluid; door locks; *DIM/NBS* **60**, No. 4, 1-24 (1976).
Energy; financial; resources; risk; costs; *SP403*, pp. 237-241 (June 1976).
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Energy; forecast; industry; iron; steel; *SP403*, pp. 121-152 (June 1976).
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Energy; legislation; regulations; state; authority; building; *NBSIR 76-986*.
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Energy; management; manufacturing; conservation; economic; *SP403*, pp. 103-111 (June 1976).
Energy; microwave measurement; nondestructive testing; thickness of coal layer; automation; coal; coal mine safety; dielectric constant; *NBSIR 76-840*.
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Energy conservation; estimation schemes; kinetics; modeling; oxidation; pyrolysis; combustion; data base; *NBSIR 75-910*.

Energy conservation; ETIP; government procurement policy; noise reduction; performance specification; technology incentives; *NBS-GCR-ETIP 73-05*.

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Energy conservation; fenestration; HVAC systems; illumination; insulation; lighting; performance standard; thermal performance; ventilation; water heating; air leakage; building design; *NBSIR 74-452*.

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Enthalpies; entropies; equation of state; ethane; internal energies; isobars; isochores; isotherms; Joule-Thomson inversion; latent heats of vaporization; melting line; orthobaric densities; specific heats; speeds of sound; vapor pressure; densities; *TN684*.
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Enthalpy of formation; ionization potential; NH_2^+; OH^+; photoionization; predissociation; Rydberg states; ammonia; appearance potential; autoionization; deuterated species; *16539.*

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Environment; gamma-ray measurements; Ge(Li) detectors; radioactivity; standards; *SP456,* pp. 173-179 (Nov. 1976).

Environment; health care; housing production; I-R 100 awards; NIKE missile; papers available; stereology; toy safety; x-ray units; computer power; computer standard; corrosion; *DIM/NBS* **60,** No. 11, 1-24 (1976).

Environment; kinetics; methylation; nucleophilic reactivity; onium salts; polar solvents; pollutants; quaternization; alkyl halides; antimony; arsenic; *16628A.*

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Environmental; frequency standards; hearing aids; high-rise buildings; metals; radiation safety; standards laboratory; synchrotron; building collapse; corrosion; energy; *DIM/NBS* **60,** No. 5, 1-24 (1976).

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Environmental matrices; extraction yields; mercury; neutron activation analysis; organomercury; solvent extraction; *SP422,* pp. 1233-1240 (Aug. 1976).

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Environmental samples; gamma-ray measurements; Ge(Li) detectors; environmental gamma-ray measurements; *SP456*, pp. 159-167 (Nov. 1976).

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Environments; glass standards; government intervention; heating/cooling; lead-paint; metric; pressure transducers; thermal comforts; weights and measures; building industry; calibration system; centigrade/celsius; computer; *DIM/NBS* **60,** No. 10, 1-24 (1976).

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Errors; probability plots; residuals; statistics; uncertainties; crystallographic data; *NBSIR 76-1102*.

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ETIP; government procurement policy; noise reduction; performance specification; technology incentives; *NBS-GCR-ETIP 73-04.*

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ETIP; government procurement policy; technology incentives; energy conservation; *NBS-GCR-ETIP 73-06.*

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Failure prevention; mechanical failure; mechanical malfunction; quality assurance; reactor systems and components; safety standards; *SP423,* pp. 143-151 (Apr. 1976).

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Falls; flows; landslides; mechanisms; slides; avalanches; earthquakes; *SP444,* pp. III-52—III-71 (Apr. 1976).

Falsework; formwork; loads; reshoring; safety; shoring; standards; building; codes; concrete; construction; *BSS80.*

Far field intensity; laser windows; thermal distortion; thermal lensing; ZnSe; *SP435,* pp. 142-147 (Apr. 1976).

Far infrared; Josephson effect; strong electron-phonon coupling; superconductivity; electron tunneling; electronic devices; *16478.*

Far ultraviolet spectroscopy; ion absorption spectrum; ion photoionization; laser ionization; photoionization resonances; sodium; *16415.*

Faraday; silver; coulometry; electrochemical equivalent; electrochemical equivalent of silver; *15922.*

Faraday effect; ferromagnetic semiconductor; hot-pressed; infrared transmission; laser induced damage; optical isolation; $CdCr_2S_4$; chalcogenide spinel; *SP462,* pp. 126-135 (Dec. 1976).

Fashion; flammability; laser measurement; science; air conditioners; attic fans; basic research; chemical thermodynamics; door security; Elliot Richardson; energy conservation; engineering; *DIM/NBS* **60,** No. 6, 1-24 (1976).

Fast neutron; tissue equivalent; calorimeter; dosimetry; *SP456,* pp. 327-333 (Nov. 1976).

Fast neutron activation analysis; fast particle activation analysis; interferences; primary interference reactions; systematic errors; trace analysis; accuracy; activation analysis; analytical chemistry; charged particle activation analysis; *SP422,* pp. 1189-1214 (Aug. 1976).

Fast neutrons; initial spectra; microdosimetric parameters; nuclear data; slowing-down spectra; energy deposition spectra; *15950.*

Fast particle activation analysis; interferences; primary interference reactions; systematic errors; trace analysis; accuracy; activation analysis; analytical chemistry; charged particle activation analysis; cross sections; *SP422,* pp. 1189-1214 (Aug. 1976).

Fast plating; fatigue strength; grinding; hardness; stress; tensile strength; wear; corrosion; crack-free chromium; electroplating; *SP452,* pp. 56-63 (Sept. 1976).

Fast risetime; flat pulse baseline/topline; pulse generator; step waveform; tunnel diode; directional coupler; *U.S. Patent 3,967,140.*

Fatalities; fire fighter; occupational safety and health; *NBS-GCR-76-60.*

Fatigue; fiber composites; liquid helium; low temperature tests; mechanical properties; cryogenics; *16194.*

Fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity; composites; copper alloys; cryogenic temperatures; elastic properties; engineering materials; *NBSIR 75-828.*

Fatigue; fracture; iron alloys; mechanical properties; nickel alloys; superconducting machinery; thermal conductivity; aluminum alloys; composites; cryogenic temperatures; elastic properties; engineering materials; *NBSIR 76-839.*

Fatigue; fracture; iron alloys; cryogenic temperatures; maraging steels; mechanical properties; nickel alloys; phenolformaldehyde; stainless steels; superconducting machinery; thermal conductivity; titanium alloys; aluminum alloys; composites; elastic properties; *NBSIR 76-848.*

Fatigue; fracture; laboratory automation; mechanical testing; plasticity; polyvinyl chloride; servo-hydraulic system; viscoelasticity; yield point; biaxial; *16626.*

Fatigue; fracture toughness; low temperature tests; mechanical properties; titanium alloy; electron beam welding; *NBSIR 76-836.*

Fatigue; Kaiser's effect; acoustic emission; amorphous polymer; crazing; *16417.*

Fatigue; lubricant film thickness; scuffing; wear; contact lubrication; elastohydrodynamic contacts; *SP423,* pp. 41-54 (Apr. 1976).

Fatigue crack growth; fatigue failure; metal fatigue; crack initiation; crack propagation; *SP423,* pp. 13-24 (Apr. 1976).

Fatigue crack propagation; fracture toughness; J-integral; low temperature tests; titanium alloys; *16531.*

Fatigue cracks; flat bottomed holes; standards; steel; titanium; transducer calibration; ultrasonic reference blocks; acoustic emission; aluminum; *16252.*

Fatigue damage; rope, aramid-fiber; slings, cargo; terminations, rope; weathering, simulated; aramid fiber rope; breaking load, rope; cable, aramid-fiber; end fittings, rope; *NBSIR 76-1159.*

Fatigue failure; mechanical failure; mechanical reliability; stress corrosion cracking; brittle fracture; economics of failure prevention; *SP423.*

Fatigue failure; metal fatigue; crack initiation; crack propagation; fatigue crack growth; *SP423,* pp. 13-24 (Apr. 1976).

Fatigue strength; grinding; hardness; stress; tensile strength; wear; corrosion; crack-free chromium; electroplating; fast plating; *SP452,* pp. 56-63 (Sept. 1976).

Fault-tree diagrams; generic safety standards; household appliances; operations research; thermal burn hazards; burn hazards, household appliances; *NBSIR 76-1097.*

Fe; ferromagnetism; soft x-ray emission; soft x-ray spectra; transition metals; Co; Cr; *d*-band widths; electronic structure; *15780.*

Fe I; iron; iron lifetimes; lifetimes in Fe I; atomic spectra; energy levels; *J. Res.* **80A** Nos. 5 and 6, 787-797 (1976).

Feature selection; multivariate analysis; optimization techniques; pattern recognition; signal processing; spectral resolution; statistics; analytical chemistry; curve fitting; data reduction; *15964.*

Fe-Cr alloys; passive films; pitting corrosion; stainless steel; x-ray analysis; electron microscopy; *16024.*

Federal ADP installations; Federal Standard COBOL; impact evaluation; sample; software management; survey; ADP; COBOL; *NBSIR 76-1100.*

Federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change; decisionmaking; Experimental Technology Incentives Program; *NBS-GCR-ETIP 76-03.*

Federal funding of civilian R&D; federal policies; policies; private sector; R&D; technological change; decisionmaking; Experimental Technology Incentives Program; *NBS-GCR-ETIP 76-04.*

Federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology; demonstration projects; Experimental Technology Incentives Program; *NBS-GCR-ETIP 76-05.*

Federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; technology; demonstration projects; Experimental Technology Incentives Program; *NBS-GCR-ETIP 76-06.*

Federal Information Processing Standards Publication; information processing; privacy; security; terms; vocabulary; computer; data processing; definitions; *FIPS PUB 39.*

Federal Information Processing Standard; Federal Standard COBOL; software; standards conformance; COBOL; COBOL coding form; *FIPS PUB 44.*

Federal Information Processing Standards; information interchange; information processing; information systems; American National Standards; American National Standards Institute; data; data base systems; data elements; data management; *NBSIR 76-1015.*

Federal libraries; library automation; survey report; *16076.*

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Federal policies; innovation loans; R&D; small business; Small Business Administration; technological change; Experimental Technology Incentives Program; *NBS-GCR-ETIP 76-11.*

Federal policies; policies; private sector; R&D; technological change; decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; *NBS-GCR-ETIP 76-03.*

Federal policies; policies; private sector; R&D; technological change; decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; *NBS-GCR-ETIP 76-04.*

Federal regulating agency; Food and Drug Administration; radiation measurements; *SP456,* pp. 25-29 (Nov. 1976).

Federal Standard COBOL; impact evaluation; sample; software management; survey; ADP; COBOL; Federal ADP installations; *NBSIR 76-1100.*

Federal Standard COBOL; software; standards conformance; COBOL; COBOL coding form; Federal Information Processing Standard; *FIPS PUB 44.*

Federal Supply Service; life cycle costing; procurement policy; specifications; value; Experimental Technology Incentives Program (ETIP); *NBS-GCR-ETIP 76-18.*

Federal Supply Service; life cycle costing; procurement policy; specifications; value incentives; computer air conditioning units; Experimental Technology Incentives Program (ETIP); *NBS-GCR-ETIP 76-23.*

Federal technology policy; SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital; capital market imperfections; *NBS-GCR-ETIP 76-08.*

Federal technology policy; SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital; capital market imperfections; *NBS-GCR-ETIP 76-12.*

Feedback; teaching method; architectural-design teaching; assemblage; design critiques; *16020.*

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Ferric phthalocyanine; kinetics; oxygen reduction; phthalocyanine catalysts; *SP455,* pp. 253-258 (Nov. 1976).

Ferroelectrics; KDP; PZT 65/35; thallium chloride; very low temperatures; barium titanate; dielectric properties; *16491.*

Ferrograph; lube oil analysis; magnetic drain plugs; oil filters; oil monitors; particle detectors; spectrograph; chip detectors; *NBS-GCR-74-23.*

Ferrographic analysis; lubricated rubbing contact; polymer formation; *SP452,* pp. 187-191 (Sept. 1976).

Ferromagnetic semiconductor; hot-pressed; infrared transmission; laser induced damage; optical isolation; $CdCr_2S_4$; chalcogenide spinel; Faraday effect; *SP462,* pp. 126-135 (Dec. 1976).

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Ferrous alloys; localized corrosion; passivity; chemical breakdown; chloride ion; corrosion; *16018.*

FET; pi network; tank circuit; *16580.*

Fe^{2+}/Fe^{3+} reaction; formic acid oxidation; oxygen reduction; underpotential deposition; electrocatalysis; foreign metal monolayers; *SP455,* pp. 191-200 (Nov. 1976).

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Fe_3O_4; high-voltage electron microscopy; *in situ* hematite; magnetite; electron microscopy; Fe_2O_3; *16292.*

Fe-57 Mössbauer spectra; Mössbauer spectra; backscattering measurements; *16387.*

FFACTS; fire accidents; fire data systems; fire hazards; fires; hazard analysis; NEISS; plastics flammability; product safety; accident data; data systems; fabric flammability; *16361.*

FFACTS; garments; ignition sources; space heaters; burns; fabric fires; *NBSIR 76-1014.*

FFACTS system; fire; flammable fabrics; NFPA; curtains; draperies; *NBSIR 75-902.*
FFT; Fourier transform; Fourier transform frequency; mechanical shock; shock generator; accelerometer; calibration; *16128.*
Fiber composites; liquid helium; low temperature tests; mechanical properties; cryogenics; fatigue; *16194.*
Fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe; broadband antenna; electromagnetic compatibility; *16210.*
Fiber optics; field strength measurement; isolated EMC antenna; sensitive isotropic probe; electromagnetic compatibility; *NBSIR 75-819.*
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Fiberglass-reinforced plastics; flammability; guy insulators; high-voltage tests; insulators, tower guy; Loran C; pultruded rods; rods, insulator; breakdown, electrical; failure analysis; *NBSIR 76-1136.*
Fibers; finishes; flame retardant treatments; nylon; wool; cotton; cotton/polyester; extinguishment; fabric flammability; fabrics; *NBS-GCR-76-71.*
Field data; ground response; seismic waves; seismometer; soil-structure interaction; earthquake; *SP444,* pp. III-13—III-23 (Apr. 1976).
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Field emission; surface density of states; transfer Hamiltonian; *16418.*
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Finite element analysis; joints; nonlinear analysis; single-lap-joint bending; spotwelded joints; weldbonded joints; bonded joints; computer simulation; cyclic loading; debond analysis; *16147.*

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Fire; guardrail; high-capacity; mathematics; mercury; performance standard; pressure transducers; SRM; surgical implants; testing; thermal transients; architectural heritage; *DIM/NBS* **60,** No. 8, 1-24 (1976).

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Firebug; impulse generators; MHD electrode materials; optical standards; safety wheels; bike regulations; bomb disarmament; computer auditing; energy options; explosive vapor detectors; *DIM/NBS* **60,** No. 7, 1-24 (1976).

Firemen's turnout coats; use type tests for comfort and effectiveness; clothing; *NBS-GCR-74-25.*

Fires; fire data; fire hazard; fire injuries; fire investigation; fire loss; fire reporting; *16139.*

Fires; hazard analysis; NEISS; plastics flammability; product safety; accident data; data systems; fabric flammability; FFACTS; fire accidents; fire data systems; fire hazards; *16361.*

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Fires; loads; safety; surveys; buildings; *16087.*

Fires; optical density; room furnishings; smoke production; smoke tests; building materials; *16557.*

Firesetting; psychopathic personality; arson; *15837.*

Fiscal administration software; grant/contract software; personnel management software; proposal/award software; research administration; software exchange; software summary; software survey; space management software; university systems; directory; *TN916.*

Fish; heavy metal; tissue; trace element analysis; water pollution; atomic absorption; bluegills; cadmium; *SP422,* pp. 1063-1072 (Aug. 1976).

Fish; mini-computer; sample preparation; toxic metals; trace determination; aquatic insects; atomic absorption; clean room; *SP422,* pp. 627-632 (Aug. 1976).

Fish analysis; sample size variations; trace analysis; trace metals; atomic absorption spectroscopy; *SP422,* pp. 163-172 (Aug. 1976).

Fission radiography; solid dielectric track recorders; ^{239}Pu track; alpha particle tracks; *SP422,* pp. 1132-1142 (Aug. 1976).

Fixed transmitter; FM transmitter; law enforcement; transmitter; base station transmitter; communications; *16286.*

Flame calorimetry of fluorine and fluorides; procedures, experimental for handling fluorine; bomb calorimetry with fluorine; enthalpy of formation, fluorides; *16100.*

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Flame detectors; flammability tests; hazard analysis; interior furnishings; toxicity; bibliographies; building fires; construction materials; fire departments; fire detection system; fire tests; *NBSIR 76-1120.*

Flame detectors; heat detectors; hospitals; hotels; maintenance; nursing homes; reliability; schools; smoke detectors; atriums; fire detection; *16179.*

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Flame emissivity; heat transfer; pyrolysis; radiant heat; thermal inertia; ASTM Standard E119; building construction; charring; combustion; fire endurance; fire test; *NBS-GCR-75-50.*

Flame extinction; flame temperature; flame velocity; flammability; flammability limits; oxygen index test; thermodynamics; chemical kinetics; diffusion flames; *NBSIR 76-1076.*

Flame polishing; fused silica; hydroxyl; ion polishing; polishing; roughness; surface damage; thin films; threshold; damage threshold; etching; *SP462,* pp. 310-314 (Dec. 1976).

Flame retardancy; mass spectrometry; optical spectroscopy; phosphorus; polyester; *16037.*

Flame retardant; oxidation rate; stibinic acid; trimethylarsine; trimethylstibine; antimony; antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; *16628.*

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Flame retardant monomers; flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; phosphorus flame retardants; polyester; precondensates; radiation grafting; antimony oxide; bromine; bromine flame retardants; calorimetry; cotton; *NBS-GCR-ETIP 76-22.*

Flame retardant treatments; nylon; wool; cotton; cotton/polyester; extinguishment; fabric flammability; fabrics; fibers; finishes; *NBS-GCR-76-71.*

Flame retardant treatments; phosphorous acids; pyrolysis; ramie; rayon; sulfur; cellulosic fibers; combustion; cotton fibers; *NBS-GCR-73-4.*

Flame retardants; flammability; phosphorus; polyester; rayon; treatments; cotton; fabrics; *NBS-GCR-73-16.*

Flame retardants; flammability; R&D contracting; radiation grafting; research consortia; cotton polyester blends; ETIP; *NBS-GCR-ETIP 75-01.*

Flame retardants; hand modifiers; inherently flame retardant polyester; phosphazenes; phosphorus flame retardants; polyester; precondensates; radiation grafting; antimony oxide; bromine; bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; *NBS-GCR-ETIP 76-22.*

Flame spread; flame spread rate; surfaces; textiles; edges; fabric construction; fabric flammability; fire spread; *NBS-GCR-75-34.*

Flame spread; flammability; full-scale fire tests; laboratory fire tests; Metrorail cars; neoprene; smoke; transportation; urethane; *NBSIR 75-971.*

Flame spread; floor coverings; flooring radiant panel test; ignition sources; pill test; room fires; carpet systems; carpets; fire safety; *NBSIR 76-1013.*

Flame spread; fluid flow; laser doppler velocimetry; liquid fuels; solid fuels; surface tension; combustion models; *NBS-GCR-76-79.*

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Flame spread; heat release rate; ignition; reduced scale models; room fires; fire tests; *NBSIR 76-1052.*

Flame spread; instability; radiant flux; α-cellulose; *16107.*

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Flame spread rate; surfaces; textiles; edges; fabric construction; fabric flammability; fire spread; flame spread; *NBS-GCR-75-34.*

Flame temperature; flame velocity; flammability; flammability limits; oxygen index test; thermodynamics; chemical kinetics; diffusion flames; flame extinction; *NBSIR 76-1076.*

Flame velocity; flammability; flammability limits; oxygen index test; thermodynamics; chemical kinetics; diffusion flames; flame extinction; flame temperature; *NBSIR 76-1076.*

Flameless atomic absorption; freshwater; interlaboratory comparison; method evaluation; trace metal analysis; accuracy; *SP422,* pp. 247-265 (Aug. 1976).

Flameless atomic absorption; interstitial water; Lake Superior chemical analysis; trace element water analysis; water filtra-

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Flameless atomic absorption; volatile chromium compounds; biological materials; biological standards; chromium; *SP422*, pp. 605-610 (Aug. 1976).

Flameless atomic absorption spectroscopy; laser Raman spectroscopy; nuclear magnetic resonance spectroscopy; phenylmercuric acetate; volatilization; bacteria; elemental mercury; *15897*.

Flameless atomic spectrophotometry; gas chromatography; graphite furnace; methylation of metals; microbial transformation; speciation; volatile metal compounds; detection; *16409*.

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Flammability; building design; consumer protection; fire control; fire detection; fire research; fire spread; *SP416, 1976 Edition*.

Flammability; burn, fabric; fabric, burn; *NBS-GCR-73-15*.

Flammability; flammability limits; oxygen index test; thermodynamics; chemical kinetics; diffusion flames; flame extinction; flame temperature; flame velocity; *NBSIR 76-1076*.

Flammability; floor coverings; pad; underlayments; carpets; fire; *NBSIR 76-1018*.

Flammability; full-scale fire tests; laboratory fire tests; Metrorail cars; neoprene; smoke; transportation; urethane; flame spread; *NBSIR 75-971*.

Flammability; glass fiber; carpet; corridor test; fire testing; *NBSIR 75-782*.

Flammability; guy insulators; high-voltage tests; insulators, tower guy; Loran C; pultruded rods; rods, insulator; breakdown, electrical; failure analysis; fiberglass-reinforced plastics; *NBSIR 76-1136*.

Flammability; heat flux; standards; tents; tests; uniforms; upholstered furniture; apparel; burn injury; carpets; draperies; fabrics; *16144*.

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Flammability; laser measurement; science; air conditioners; attic fans; basic research; chemical thermodynamics; door security; Elliot Richardson; energy conservation; engineering; fashion; *DIM/NBS* **60**, No. 6, 1-24 (1976).

Flammability; phosphorus; polyester; rayon; treatments; cotton; fabrics; flame retardants; *NBS-GCR-73-16*.

Flammability; polyester/cotton fabrics; cotton fabrics; extinguishability; *16149*.

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Flammability testing; heat conductivity; simulation; skin; apparel fabrics; fire hazard; *NBS-GCR-73-14*.

Flammability testing; heat transfer; smoldering fabrics; fabric flammability; *NBS-GCR-73-2*.

Flammability testing; ignition; skin; thermal burns; thermal measurements; apparel fabrics; fabrics; fire hazards; *NBS-GCR-73-6*.

Flammability testing; ignition; thermal burns; apparel fabrics; fabrics; fire hazard; *NBS-GCR-73-7*.

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Flammability testing; simulation; skin; thermal burns; apparel fabrics; fabrics; fire hazard; *NBS-GCR-73-13*.

Flammability testing; skin; thermal burns; thermal measurements; apparel fabrics; fabrics; fire hazard; *NBS-GCR-73-9*.

Flammability testing; thermal measurements; thermodynamic properties; apparel fabric; fabric; fire hazard; *NBS-GCR-73-8*.

Flammability tests; garments; heat transfer; standards; apparel; burn injury; ease of ignition; fabrics; fire; *NBSIR 76-1072*.

Flammability tests; hazard analysis; interior furnishings; toxicity; bibliographies; building fires; construction materials; fire departments; fire detection system; fire tests; flame detectors; *NBSIR 76-1120*.

Flammable fabrics; ignition hazards; ignition sources; lighters; matches; burns; fabric fires; fire injuries; *NBS-GCR-74-32*.

Flammable fabrics; NFPA; curtains; draperies; FFACTS system; fire; *NBSIR 75-902*.

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Flare; image intensifiers; law enforcement; light equivalent background; light induced; optical gain; night vision; contrast transfer function; *16239*.

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Flaw detection; nondestructive inspection; acoustic emission; acoustics; *16269*.

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Floor coverings; horizontal; ignition; ignition time; pilot ignition; radiant heat flux; carpets; *NBSIR 75-967*.
Floor coverings; pad; underlayments; carpets; fire; flammability; *NBSIR 76-1018*.
Floor slipperiness; slipperiness tester; static coefficient of friction measurement; *U.S. Patent 3,975,940*.
Floor surface friction; occupancy safety; slip-resistance; slip-resistance testers; walking friction; building safety; *TN895*.
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Floor systems; human response; random process; spectral analysis; vibration; analysis; experimental; *NBSIR 75-951*.
Floor systems; human responses; performance criteria; serviceability; static; vibration; deflection; dynamic; *TN900*.
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Fluorescence method analysis; rare earths, as an internal reference; rare earths, determination of trace amounts; *SP422*, pp. 1103-1107 (Aug. 1976).
Fluorescence quantum efficiency; fluorescence quantum yields; fluorescence spectrum; fluorescence standards; molecular fluorescence parameters; observed (technical) fluorescence parameters; polarization; *J. Res.* **80A** No. 3, 389-399 (1976).
Fluorescence quantum yield; laser dyes; molecular structure;

oxazine dyes; quenching; xanthene dyes; aminocoumarins; carbazine dyes; deuterium effect; *J. Res.* **80A** No. 3, 421-428 (1976).
Fluorescence quantum yields; fluorescence spectrum; fluorescence standards; molecular fluorescence parameters; observed (technical) fluorescence parameters; polarization; radiative and nonradiative transition probabilities; *J. Res.* **80A** No. 3, 389-399 (1976).
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Forging; isostatic; polishing; quartz; shaping; closed die; *SP462,* pp. 95-99 (Dec. 1976).
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Housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; standards; computer techniques; construction; enforcement process; *NBSIR 76-1058.*

Housing; hurricanes; low-rise buildings; natural disaster; structural connections; typhoons; wind loads; buildings; codes and standards; *NBSIR 75-790.*

Housing; lead paint; lead poisoning; surveys; blood; blood lead; children; *NBSIR 76-1024.*

Housing; lead-based paint; lead poisoning; abatement; building economics; building materials; economic analysis; *TN922.*

Housing; lead-based paint; lead poisoning; paint removal; abatement; barrier materials; building materials; children; *NBSIR 75-974.*

Housing; low-cost housing; low-rise buildings; wind; Bangladesh; *NBS-GCR-76-74.*

Housing; performance specification; prefabricated dwelling; standards; structural design; earthquake; *SP444,* pp. IV-55—IV-69 (Apr. 1976).

Housing; Peru; technical aid; adobe; cane; earthquake; *SP444,* pp. VI-16—VI-24 (Apr. 1976).

Housing demand, supply, needs; housing rehabilitation; land economics; market adjustments; optimization and feasibility; rehabilitation, conservation; housing; *NBSIR 76-1043.*

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available; stereology; toy safety; x-ray units; computer power; computer standard; corrosion; environment; health care; *DIM/NBS* **60**, No. 11, 1-24 (1976).

Housing rehabilitation; land economics; market adjustments; optimization and feasibility; rehabilitation, conservation; housing; housing demand, supply, needs; *NBSIR 76-1043.*

Housing systems; industrialized housing; mass per unit area; Operation BREAKTHROUGH; U-value; building classification; building thermal mass; building thermal performance; building thermal time constant; *NBSIR 75-678.*

Human behavior; institutions; mapping; models; nursing homes; realms; building fires; case studies; critical events; decisions; episodes; fires; home for the aged; hospital fires; *NBS-GCR-76-73.*

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Human systems; measuring instruments; research assistants; test device evaluation; criteria; decision making; *16091.*

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Hurricanes; natural hazards; structural engineering; tornados; wind; buildings; damage; disaster; dynamic analysis; earthquakes; *NBS-GCR-75-36.*

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Industrial lead hygiene; interlaboratory correlations; lead hygiene control; occupational exposure standard criteria; occupational health control; precision; trace element analyses; accuracy; blood lead analyses; clinical chemistry; *SP422*, pp. 275-282 (Aug. 1976).

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Infrared lasers; interferometry; stress birefringence; thermal distortion; windows; *SP435*, pp. 126-141 (Apr. 1976).

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KCl; laser window coatings; ZnS; CeF_3; CO_2 pulsed laser damage; coating topography; *SP435*, pp. 236-243 (Apr. 1976).

KCl; laser windows; optical figure; polishing; scattered light; surface absorption; alkali-halide; *SP435*, pp. 20-28 (Apr. 1976).

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Potable water protection; plumbing guide criteria; backflow; backflow prevention devices; back pressure; backsiphonage; guide criteria; *NBSIR 76-1020.*
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Potassium activity; synthetic coal slags; system K_2O-CaO-Al_2O_3-SiO_2; vaporization; crystallization; magnetohydrodynamics; *16457*.

Potassium antimonate; sodium antimonate; sodium antimony oxyfluoride; alkali antimonates; crystal growth; ionic conductors; *J. Res.* **80A** Nos. 5 and 6, 761-774 (1976).

Potassium chloride; ultrasonics; bulk modulus; equation of state; high pressure; phase transitions; *16029*.

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Potassium iodide; calibration cell; chlorine concentration; chlorine monitor; electrochemical calibration; internal calibration; iodine detection; *U.S. Patent 3,966,413*.

Potassium pentaborate; u.v. generation; doubling; laser; *15932*.

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Potentiometer; programmable potentiometer; self-balancing potentiometers; thermometry; automatic potentiometry; automation; calorimetry; Diesselhorst ring; *J. Res.* **80A** No. 4, 669-675 (July-Aug. 1976).

Pound; weight; force; kilogram; mass; *16394*.

Powder coating; salt water; solid lubrication; abrasion; corrosion protection; friction; marine environment; *SP452*, pp. 25-30 (Sept. 1976).

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Precision; quality control; systematic error; Youden plot; analytical performance; between-run; calibration; *SP422*, pp. 141-150 (Aug. 1976).

Precision; radiochemical separations; silver; accuracy; activation analysis; copper; gold; hafnium; palladium; platinum; *SP422*, pp. 1157-1164 (Aug. 1976).

Precision; reference methods; standard reference material; systematic errors; accuracy; accurate measurement system; *SP422*, pp. 41-63 (Aug. 1976).

Precision; round-robin experiments; trace element analysis; accuracy; activation analysis; air filter analysis; analytical quality control; atomic absorption spectrometry; environmental analysis; fresh water analysis; intercomparisons; *SP422*, pp. 189-197 (Aug. 1976).

Precision; therapy; TLD; dosimetry; ion chamber; patient; *SP456*, pp. 343-350 (Nov. 1976).

Precision; trace element analyses; accuracy; blood lead analyses; clinical chemistry; industrial lead hygiene; interlaboratory correlations; lead hygiene control; occupational exposure standard criteria; occupational health control; *SP422*, pp. 275-282 (Aug. 1976).

Precision; x-ray fluorescence; accuracy; atomic absorption; environment; neutron activation analysis; *SP422*, pp. 239-245 (Aug. 1976).

Precision attenuator; sensor; waveguide-below-cutoff; absolute (unambiguous) readout; piston; *NBSIR 76-833*.

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Precision measurements; radio star; satellite communications; error analysis; G/T; *NBSIR 76-842*.

Precision mercury manometer; triple point of water; vapor pressure of water; *16096*.

Precision mercury manometer; triple point of water; vapor pressure of water; *J. Res.* **80A** No. 3, 505-521 (1976).

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Precision of measurement; repeatability; reproducibility; test methods; transformations; weighting; interlaboratory comparisons; invariance; models; precision; *15909*.

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Predicting product reliability; design engineering; material deterioration; mechanical failure; mechanical integrity; mechanical reliability; performance envelope; *SP423*, pp. 199-208 (Apr. 1976).

Predissociation; radiative recombination; $^5\Sigma_g^+$; electronic structure; energy curve; N_2; *16442*.

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Prefabricated dwelling; standards; structural design; earthquake; housing; performance specification; *SP444*, pp. IV-55 – IV-69 (Apr. 1976).

Prefabrication; zoning; building codes; building laws and regulations; building materials – testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; *NBS-GCR-73-19*.

Preferential oxidation; temperature gradient; thermal gradient; thermocouple; thermoelectric stability; aging; calibration change; gradient; high temperature (700 to 2000 °C); iridium; iridium-rhodium alloy; noble-metal thermocouple; oxidation; platinum; *16158*.

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Pressure; pressure measurement; calibration; calibration chain; *NBSIR 75-931*.

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Pressure measurement; calibration; calibration chain; pressure; *NBSIR 75-931*.

Pressure measurement; pressure transducer; thermal transient; transducer; zero shift; calibration; dynamic; electronic flash; photographic flashbulb; pressure; *TN905*.

Pressure measurement; pressure transducer; pressure transducer response; response; thermal transient; transducer; zero shift; calibration; dynamic; electronic flash; photoflash bulb; pressure; *NBSIR 76-1038*.

Pressure probe shroud; static pressure; weatherproof pressure probe; wind field pressure measurements; ambient pressure probe; omnidirectional pressure probe; *U.S. Patent 3,950,995*.

Pressure seal; pressure vessel; resistance; resistance thermometer; test; thermometer; thermometer leads; thermostated bath; vacuum; water tight; bridge; deep-sea thermometer; high pressure; oceanographic thermometer; platinum resistance thermometer; pressure; *TN894*.

Pressure source; pressure transducer; sinusoidal pressure; transducer; calibration; dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; *TN914*.

Pressure source; pressure transducer; sinusoidal; space shuttle; transducer; bias pressure; calibration; dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; *TN927*.

Pressure transducer; pressure transducer response; response; thermal transient; transducer; zero shift; calibration; dynamic;

electronic flash; photoflash bulb; pressure; pressure measurement; *NBSIR 76-1038.*

Pressure transducer; protective coatings; thermal radiant-energy response; thermal transient response; transducer; coatings; photoflash bulb; *NBSIR 76-1060.*

Pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift; coatings; dynamic; dynamic response; *NBSIR 76-1144.*

Pressure transducer; sinusoidal pressure; transducer; calibration; dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; *TN914.*

Pressure transducer; sinusoidal; space shuttle; transducer; bias pressure; calibration; dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; *TN927.*

Pressure transducer; thermal transient; transducer; zero shift; calibration; dynamic; electronic flash; photographic flashbulb; pressure; pressure measurement; *TN905.*

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Pressure transducers; SRM; surgical implants; testing; thermal transients; architectural heritage; fire; guardrail; high-capacity; mathematics; mercury; performance standard; *DIM/NBS* **60,** No. 8, 1-24 (1976).

Pressure transducers; thermal comforts; weights and measures; building industry; calibration system; centigrade/celsius; computer; electrical industries; environments; glass standards; government intervention; heating/cooling; *DIM/NBS* **60,** No. 10, 1-24 (1976).

Pressure vessel; resistance; resistance thermometer; test; thermometer; thermometer leads; thermostated bath; vacuum; water tight; bridge; deep-sea thermometer; high pressure; oceanographic thermometer; platinum resistance thermometer; pressure; pressure intensifier; *TN894.*

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Primary standards; properties; atom; energy generation; industrial technology; molecule; *NBSIR 75-944.*

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Privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs; computer security; confidentiality; cost model; data security costs; PL 93-597; *TN906.*

Privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs; computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; *NBSIR 76-985.*

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Privacy; security; terms; vocabulary; computer; data processing; definitions; Federal Information Processing Standards Publication; information processing; *FIPS PUB 39.*

Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs; computer security; confidentiality; cost model; data security costs; PL 93-597; privacy; *TN906.*

Privacy Act of 1974; privacy compliance techniques; privacy costs; privacy model; security costs; computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; privacy; *NBSIR 76-985.*

Privacy compliance techniques; privacy costs; privacy model; security costs; computer security; confidentiality; cost model; data security costs; PL 93-597; privacy; Privacy Act of 1974; *TN906.*

Privacy compliance techniques; privacy costs; privacy model; security costs; computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; privacy; Privacy Act of 1974; *NBSIR 76-985.*

Privacy costs; privacy model; security costs; computer security; confidentiality; cost model; data security costs; PL 93-597; privacy; Privacy Act of 1974; privacy compliance techniques; *TN906.*

Privacy costs; privacy model; security costs; computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; privacy; Privacy Act of 1974; privacy compliance techniques; *NBSIR 76-985.*

Privacy model; security costs; computer security; confidentiality; cost model; data security costs; PL 93-597; privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; *TN906.*

Privacy model; security costs; computer model; computer security; confidentiality; cost model; data security costs; PL-93-579; privacy; Privacy Act of 1974; privacy compliance techniques; privacy costs; *NBSIR 76-985.*

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Problems with patrol cars; state of the art survey; functional requirements; patrol cars; performance of patrol cars; police patrol cars; *NBSIR 75-960.*

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Procurement experiments; energy efficient products; Experimental Technology Incentives Program; gas ranges; life cycle costing; *NBS-GCR-ETIP 76-15.*

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Procurement experiments; refrigerator-freezers; energy-efficient products; Experimental Technology Incentives Program; life-cycle costing; *NBSIR 75-954.*

Procurement experiments; refrigerators; energy efficient products; Experimental Technology Incentives Program; life cycle costing; *NBS-GCR-ETIP 76-10.*

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Procurement policy; state government; bid evaluation; Experimental Technology Incentives Program (ETIP); innovation; life cycle costing; local government; *NBS-GCR-ETIP 76-17.*

Procurement procedures; proposal evaluation procedures; proposal preparation procedures; evaluation systems; Experimental Technology Incentives Program; procurement experiments; *NBSIR 76-1124.*

Product performance; product reliability; product testing; consumer products; marketing; mechanical failure; *SP423,* pp. 209-212 (Apr. 1976).

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Product safety; accident data; data systems; fabric flammability; FFACTS; fire accidents; fire data systems; fire hazards; fires; hazard analysis; NEISS; plastics flammability; *16361.*

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Proof testing; slow crack growth; unloading; failure probabilities; lifetime assurance; *16039.*

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Propanone (acetone); torsional frequencies; 2-butanone (methyl ethyl ketone); enthalpy; entropy; equilibrium constant of formation; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; *JPCRD* **5**, No. 2, 319-328 (1976).

Proper time; UTC; atomic clocks; clock acceleration effect; definition of the second; frequency accuracy; frequency standards; general relativity; gravitational redshift; primary frequency standards; *16236.*

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Properties; test methods; nonpolymeric constituents in plastics; plastics testing; polymer analysis; *16225.*

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Properties of semiconductors; semiconductors; thermoelectric power; band structure; *16161.*

Property; system; test method; ASTM; classification; fire hazard; participation; *16124.*

Property measurement test; standard test methods; aging test; building elements and materials; degradation factors; durability; *NBSIR 75-955.*

Proportional counters; radioactivity standardization; xenon-133, 131m; argon-37; direct standardization; environmental radioactivity; internal gas counters; isotope separator; krypton-85; *15948.*

Proportional limit; crack propagation; determination of stress; measurement; mechanical tests; plastic deformation; *16468.*

Proportional limit; flow surface; multiaxial stresses; plasticity; *15802.*

Proposal evaluation procedures; proposal preparation procedures; evaluation systems; Experimental Technology Incentives Program; procurement experiments; procurement procedures; *NBSIR 76-1124.*

Proposal preparation procedures; evaluation systems; Experimental Technology Incentives Program; procurement experiments; procurement procedures; proposal evaluation procedures; *NBSIR 76-1124.*

Proposal/award software; research administration; software exchange; software summary; software survey; space management software; university systems; directory; equipment management software; fiscal administration software; grant/contract software; *TN916.*

Protactinium; rare earth; sliding spark discharge lamp; spec-

trum; uranium; actinide; atomic energy levels; isoelectronic sequence; *15990.*

Protection; protective equipment; energy absorption; impact test; *NBS-GCR-74-24.*

Protection; reliable software; reliability; security; small protection domains; types; capability; capability-based addressing; computer security; extended-type objects; operating system structures; *TN919.*

Protective clothing; smoke inhalation; standards; breathing apparatus; closed loop breathing apparatus; equipment design; fire fighters; fire fighting; fire fighting equipment; fire gases; open loop breathing apparatus; *NBS-GCR-73-10.*

Protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; zero shift; coatings; dynamic; dynamic response; pressure transducer; *NBSIR 76-1144.*

Protective coatings; thermal radiant-energy response; thermal transient response; transducer; coatings; photoflash bulb; pressure transducer; *NBSIR 76-1060.*

Protective equipment; energy absorption; impact test; protection; *NBS-GCR-74-24.*

Protective films; moisture resistance; sodium chloride; arsenic trisulphide; ion planing; *SP435,* pp. 14-19 (Apr. 1976).

Protective headgear; safety; test methods; head injury; helmets; math model; *NBSIR 76-1107.*

Protein adsorption; conformation adsorbed proteins; ellipsometry; infrared bound fraction; *16427.*

Protein adsorption; protein conformation; blood proteins; infrared bound fraction; *15707.*

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Protein conformation; blood proteins; infrared bound fraction; protein adsorption; *15707.*

Proteins; solid standards; antibodies; antigens; biological polymers; immunochemical analysis; light scattering; polymers; *J. Res.* **80A** No. 4, 605-608 (1976).

Protocol; standards; computer networks; data communications; data networks; networks; packet switching; *16576.*

Protocols; automated reading technology; circuitry; computer applications; computer engineering; distributed systems; interface standards; memory technology; *16553.*

Protocols; teleprocessing; access procedures; command language; computer networks; job control language; macros; minicomputers; *TN917.*

Proton affinity; proton transfer; basicity; bibliography, appearance potential; heat of formation; ion-molecule equilibrium; *NBSIR 76-1061.*

Proton affinity; proton transfer; rate coefficients; CCl_2, CF_2; CCl_2H^+, CF_2H^+; displacement reactions; four-center reactions; ion molecule reactions; *16598.*

Proton transfer; basicity; bibliography, appearance potential; heat of formation; ion-molecule equilibrium; proton affinity; *NBSIR 76-1061.*

Proton transfer; radiation chemistry; hydride transfer; ion clustering; ion-molecule reactions; *15816.*

Proton transfer; rate coefficients; CCl_2, CF_2; CCl_2H^+, CF_2H^+; displacement reactions; four-center reactions; ion molecule reactions; proton affinity; *16598.*

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Pseudointersection graph; set covering; clique; clique graph; intersection graph; *J. Res.* **80B** No. 4, 441-445 (1976).

Pseudopentagonal; stacking fault; twin; wedge; crystal; disclination; dislocation; *15767.*

Pseudopotentials; molecular structure; *15815.*

Pseudopotentials; self-consistent field; valence electrons; basis functions; configuration mixing; dipole moments; electronic structure of molecules; Hartree-Fock; integrals, evaluation of; molecular structure; orbitals; potential energy curves; *16611.*

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Public safety; safety responsibility; construction safety; construction surety; degradation of safety with age and use; maintenance of safety; *SP423,* pp. 165-170 (Apr. 1976).

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Public services; social impact of automation; automation technology; economic impact of automation; productivity improvement; *SP448.*

Publications; abstracts; Center for Building Technology; key words; *SP457.*

Publications; abstracts; NBS publications; key words; *SP305. Supplement 7.*

Publications; reference data; journal; professional societies; *15734.*

Puerto Rico; replicates; sediments; standard; trace elements; accuracy; Atomic Absorption Spectrometry; Caribbean; precision; *SP422,* pp. 1089-1102 (Aug. 1976).

Pull rate; pull strength; resolution-of-forces; semiconductor devices; ultrasonic bonding; wire bond; bond angle; bonding; bond pull test; bond-to-bond spacing; large wire; loop height; microelectronics; nondestructive bond pull test; position of hook; *SP400-18.*

Pull strength; resolution-of-forces; semiconductor devices; ultrasonic bonding; wire bond; bond angle; bonding; bond pull test; bond-to-bond spacing; large wire; loop height; microelectronics; nondestructive bond pull test; position of hook; pull rate; *SP400-18.*

Pull test; resistivity; Rutherford backscattering; scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; shear test; sheet resistors; silicon; silicon on sapphire; *SP400-19.*

Pull test; resistivity; scanning acoustic microscope; scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; silicon on sapphire; spreading resistance; *SP400-25.*

Pull-out strength; splitting tensile strength; compressive strength; concrete; maturity; mechanical properties; nondestructive evaluation; *TN932.*

Pullout tests; bond strength; coated reinforcing bars; evaluation; organic coatings; *15782.*

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Pulse discharge; collision model; early afterglow; electron temperature; helium metastables; helium plasma; *15958.*

Pulse echo; steel ultrasonic standards; titanium ultrasonic standards; ultrasonics; aluminum ultrasonic standards; ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; *NBSIR 76-984.*

Pulse generator; step waveform; tunnel diode; directional coupler; fast risetime; flat pulse baseline/topline; *U.S. Patent 3,967,140.*

Pulse laser power; electrically calibrated pyroelectric detector; gold-black; piezoelectric; *16135.*

Pulse measurement; automation; electrical measurements; electrooptics; high voltage measurement; Kerr effect; optical coupling; *15718.*

Pulse measurement; spectrum; spectrum amplitude; calibration; Fourier transform; impulse generator; *16463.*

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Pulse polarography; trace analysis; background correction; differential pulse polarography; dropping mercury electrode; electroanalysis; *SP422*, pp. 871-879 (Aug. 1976).

Pulse shape discrimination; tropospheric mixing; Ar-37; atmospheric radioactivity; cosmic-ray reactions; exponential distribution; low-level counting; noble gas separation; on-line computer; *15744.*

Pulse-CW equalization; pulse modulated carrier systems; rf peak pulse power; notch wattmeter; *TN682.*

Pulsed CO_2 laser damage; surface damage; 10.6 μm absorption; 10.6 μm optical components; dielectric coatings; infrared laser windows; laser heating of metal surfaces; laser mirrors; *SP462*, pp. 181-188 (Dec. 1976).

Pulsed CO_2 TEA laser damage; transmitted pulse; waveform distortion; ZnSe; KCl; NaCl; *SP435*, pp. 107-117 (Apr. 1976).

Pulsed DF laser damage; sapphire; scattering; waveform distortion; alkali-halides; alkaline-earth fluorides; bulk damage; focal spot diameter; inclusion damage; interference ripples; *SP462*, pp. 136-144 (Dec. 1976).

Pulsed laser; thermal distortion; laser windows and mirrors; optical figure; *SP462*, pp. 11-24 (Dec. 1976).

Pulsed laser damage; rare earth fluorides; zinc selenide coatings; laser antireflective coatings; materials purification requirements; *SP462*, pp. 271-278 (Dec. 1976).

Pulsed laser damage; thermal model; angle of incidence; polarization; *SP435*, pp. 41-48 (Apr. 1976).

Pulsed laser holograms; stress corrosion cracking; ultrasonic inspection; aircraft component failure; continuous wave holograms; crack detection; holographic techniques; *SP423*, pp. 93-103 (Apr. 1976).

Pulsed lasers; window damage; mirror damage; *SP435*, pp. 202-206 (Apr. 1976).

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Pulsed x rays; radiographic imaging; steady-state x rays; detector calibrations; fluorescence x-ray sources; K x-ray sources; *SP456*, pp. 41-45 (Nov. 1976).

Pulsed 10.6 μm laser damage; RAP materials; transmitted pulse cutoff; variable pulse duration; alkali halides; bulk damage; longitudinal mode control; *SP435*, pp. 118-125 (Apr. 1976).

Pulse-echo; ultrasonics; aluminum ultrasonic reference standards; ASTM-type reference standards; calibration; interim reference standard; longitudinal beam; measurement system; nondestructive evaluation; *TN924.*

Pulse-echo method; resonance method; shear modulus; sound velocity; Young's modulus; bulk modulus; compressibility; copper; copper alloys; elastic constants; Poisson ratio; *16505.*

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Pultrusions; stress-rupture testing; sunlight; ultraviolet radiation; weatherability; antenna-support materials; environmental degradation; guys, nonmetallic; marine atmospheres; plastics, fiber-reinforced; *NBSIR 76-1069.*

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Purity; reagents; accuracy; analysts; apparatus; blank; contamination; environment; *SP422*, pp. 509-539 (Aug. 1976).

Purity definition; reagent contamination; ultrapurification; analytical blanks; analytical reagents; contamination control; high-purity reagents; membrane filtration; mercury cathode electrolysis; prepurification; *SP422*, pp. 363-375 (Aug. 1976).

PVT; density; ethane; vapor pressure; *J. Res.* **80A** No. 1, 35-39 (1976).

Pyroelectric; dipoles; electret; glass; piezoelectric; polarization; polyvinyl chloride; *16277.*

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Pyrolysis; pyrophosphate; stoichiometry; whitlockite; β-tricalcium; calcification; calcium; dicalcium phosphate; octacalcium phosphate; *15996.*

Pyrolysis; radiant heat; thermal inertia; ASTM Standard E119; building construction; charring; combustion; fire endurance; fire test; flame emissivity; heat transfer; *NBS-GCR-75-50.*

Pyrolysis; radiant heat; thermal sensitivity index; calorimeter; combustion; fire test; heat release; limiting thermal index; *NBS-GCR-76-54.*

Pyrolysis; ramie; rayon; sulfur; cellulosic fibers; combustion; cotton fibers; flame retardant treatments; phosphorous acids; *NBS-GCR-73-4.*

Pyrolysis; reactive gas generator; sulfur dioxide; acetaldehyde; acrolein; formaldehyde; gas chromatography; hydrogen chloride; hydrogen cyanide; pollution; *NBSIR 76-1000.*

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Pyrometry; radiance temperature; hafnium; high-speed measurement; high temperature; melting point; *J. Res.* **80A** No. 4, 659-662 (1976).

Pyrometry; radiance temperature; tantalum; emittance; high-speed measurements; high temperature; melting point; *16426.*

Pyrophosphate; stoichiometry; whitlockite; β-tricalcium; calcification; calcium; dicalcium phosphate; octacalcium phosphate; pyrolysis; *15996.*

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Q cavity; two-ports; automatic network analyzer; *15867*.
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Quadrature; computer program; Fourier transform NMR; homonuclear lock; phase adjustment; phase correction algorithm; *15970*.
Quadrupole hyperfine interactions; saturated absorption spectroscopy; high resolution spectroscopy; methyl halides; optical heterodyne spectroscopy; *16407*.
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Quality and compatible part material; quality diamond tools; controlled environment; diamond machining; machined optics; nondistortion part support; position errors; *SP435*, pp. 75-89 (Apr. 1976).
Quality assurance; calibration; megavoltage radiotherapy; *SP456*, pp. 351-358 (Nov. 1976).
Quality assurance; quality control; radioactivity; reference methods; calibration; intercomparison studies; *SP456*, pp. 263-265 (Nov. 1976).
Quality assurance; radioactive effluents; radioanalytical data; regulations; environmental samples, laboratories; *SP456*, pp. 249-261 (Nov. 1976).
Quality assurance; radiopharmaceuticals; ^{99m}Technetium; gamma camera; nuclear medicine; *SP456*, pp. 131-138 (Nov. 1976).
Quality assurance; reactor systems and components; safety standards; failure prevention; mechanical failure; mechanical malfunction; *SP423*, pp. 143-151 (Apr. 1976).
Quality assurance measurements; x-ray quality control; diagnostic radiology; pass-fail tests; *SP456*, pp. 119-130 (Nov. 1976).
Quality control; medical physicist; radiation measurement; radiation therapy; tumor dose; *SP456*, pp. 111-118 (Nov. 1976).
Quality control; quantitative accuracy; reference materials; sampling; concentration; detectors; extraction; gas chromatography; isolation and clean-up; mass spectrometry; organic trace analysis; qualitative accuracy; *SP422*, pp. 9-34 (Aug. 1976).
Quality control; radiation measurement; radiation processing; radiation sterilization; radiochromic dyes; Red Perspex; sterility control; dosimetry; electron beams; gamma rays; physical measurements; *16648*.
Quality control; radioactivity; reference methods; calibration; intercomparison studies; quality assurance; *SP456*, pp. 263-265 (Nov. 1976).
Quality control; safety; testing; engineering, instrumentation and techniques; fluids; force; hydraulic equipment; mechanical power; noise; pressure; *16452*.
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Quality control; standards; air pollution; calibration; evaluation; inter-calibration; *15978*.
Quality control; surrogate specimens; trace elements; accuracy and precision; clinical chemistry; *SP422*, pp. 35-40 (Aug. 1976).
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Quantitative phase analysis; quantitative powder diffraction; reference intensity ratios; systematic errors in powder diffraction; calculated powder patterns; I/I_c; microabsorption effects; *15929*.
Quantitative powder diffraction; reference intensity ratios; systematic errors in powder diffraction; calculated powder patterns; I/I_c; microabsorption effects; quantitative phase analysis; *15929*.
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Quantum chemistry; transition metal complexes; catalysis; chemisorption theory; metal clusters; molecular orbitals; *SP455*, pp. 67-86 (Nov. 1976).
Quantum counters; rhodamine B chloride; spectrofluorimetry; total internal reflection; emission anisotropy; fluorescence; photodetectors; polarization; *16430*.
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Quartz; shaping; closed die; forging; isostatic; polishing; *SP462*, pp. 95-99 (Dec. 1976).

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Quenching; xanthene dyes; aminocoumarins; carbazine dyes; deuterium effect; fluorescence quantum yield; laser dyes; molecular structure; oxazine dyes; *J. Res.* **80A** No. 3, 421-428 (1976).

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R & D incentives; tissue characterization; tissue signature; ultrasonic diagnosis; ultrasound; applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; *SP453*, pp. 7-10 (Oct. 1976).

Racking; test method; vertical loads; wall panels; walls; lateral loads; loading rate; *BSS91.*

Radiance temperature; hafnium; high-speed measurement; high temperature; melting point; pyrometry; *J. Res.* **80A** No. 4, 659-662 (1976).

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Radiant heat; thermal sensitivity index; calorimeter; combustion; fire test; heat release; limiting thermal index; pyrolysis; *NBS-GCR-76-54.*

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Radiation; safety; x-ray generators; x rays; calibration; electrical measurements; electro-optics; frequency response; high voltage; Kerr effect; operational amplifier; pulses; *NBSIR 75-775.*

Radiation; sound studies; engineering; environmental; interference abatement; laboratory environments; *16009.*

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Radiation; supervoltage; therapy; dosimetry; intercomparisons; *SP456*, pp. 359-363 (Nov. 1976).

Radiation; thalium; molecules; *16094.*

Radiation calibrations; radiation control; radiation measurement assurance; radiation standards; mobile laboratory; *SP456*, pp. 47-51 (Nov. 1976).

Radiation chemistry; hydride transfer; ion clustering; ion-molecule reactions; proton transfer; *15816.*

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Radiation control; radiation measurement assurance; radiation standards; mobile laboratory; radiation calibrations; *SP456*, pp. 47-51 (Nov. 1976).

Radiation converter; ultraviolet averaging sphere; ultraviolet to visible converter; averaging sphere; averaging ultraviolet and visible light; *U.S. Patent 3,968,363.*

Radiation damage; radiation effects; digital bipolar circuits; integrated injection logic; *16180.*

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Radiation effects; digital bipolar circuits; integrated injection logic; radiation damage; *16180.*

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Radiation exposure; radiation measurement; radiation protection; *SP456*, pp. 5-11 (Nov. 1976).

Radiation grafting; antimony oxide; bromine; bromine flame retardants; calorimetry; cotton; cotton/polyester; ETIP; fabric flammability; flame retardant mechanisms; flame retardant monomers; flame retardants; hand modifiers; *NBS-GCR-ETIP 76-22.*

Radiation grafting; research consortia; cotton polyester blends; ETIP; flame retardants; flammability; R&D contracting; *NBS-GCR-ETIP 75-01.*

Radiation hardening; test patterns; test structures; hardened integrated circuits; integrated circuits; radiation effects; *NBSIR 76-1093.*

Radiation hardness; receivers; Schottky-barrier diodes; semiconductors; solid-state devices; x-band measurements; diodes; gamma rays; hardness assurance; microwave mixer diodes; mixers; neutrons; *SP400-7.*

Radiation heating; vapor pressures; AlO_2; Al_2O_3; emissivity; evaporation coefficient; Langmuir vaporization; optical pyrometry; *16540.*

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Radiation measurement assurance; radiation standards; mobile laboratory; radiation calibrations; radiation control; *SP456*, pp. 47-51 (Nov. 1976).

Radiation measurements; federal regulating agency; Food and Drug Administration; *SP456*, pp. 25-29 (Nov. 1976).

Radiation pattern; reflector; Yagi; antenna; director; driven element; gain; *TN688.*

Radiation physics; electrons; free ions; ion yields; liquid; nonpolar systems; radiation chemistry; *NSRDS-NBS57.*

Radiation processing; radiation sterilization; radiochromic dyes; Red Perspex; sterility control; dosimetry; electron beams; gamma rays; physical measurements; quality control; radiation measurement; *16648.*

Radiation protection; radiation exposure; radiation measurement; *SP456*, pp. 5-11 (Nov. 1976).

Radiation quality; secondary particle spectra; theoretical dosimetry; energy deposition spectra; microdosimetry; neutron interactions with tissue; neutrons; *16182.*

Radiation resistance; rectangular coax; shielded strip line; TEM cell; EMC measurements; *NBSIR 75-829.*

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Radiation safety; radiation therapy (ultrasonic); ultrasonics; electroacoustics; medical diagnostics; *NBSIR 75-937.*

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Reflectors; ThF_4; thin film; ZnSe; 10.6 μm; absorbing inclusions; damage statistics; laser damage; *SP435*, pp. 216-229 (Apr. 1976).

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Roots of unity; Schur matrix; compounds; induced matrices; Kronecker powers; *15955.*

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Rotating disks; singular perturbations; turning-point; viscous flow; Weber's equation; boundary-value problem; eigenvalues; parabolic cylinder functions; resonance; *16459.*

Rotating electrode voltammetry; semiconductor electrode; flat band potential; hydrogen evolution; oxide electrode; perovskite surface composition; *SP455,* pp. 229-240 (Nov. 1976).

Rotating fluids; stratified fluids; waves in fluids; buoyant flows; geophysical fluid flows; inertial waves; internal waves; *J. Res.* **80B** No. 3, 353-402 (1976).

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measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; *Monogr. 151.*

Rotating reference frame; acceleration measurement: fundamental constant; gravitational attraction; gravitational constant; *16222.*

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Rotational diffusion; ^{13}C magnetic resonance; collagen; conformation; correlation times; cyanogen bromide peptides; polypeptides; relaxation times; *16211.*

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Rotational excitation; scattering theory; sudden approximation; differential cross sections; elastic scattering; electron scattering; hydrogen molecules; momentum transfer; *15761.*

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Rotational transitions; radio astronomy; isocyanic acid; interstellar molecules; microwave spectra; molecular parameters; *JPCRD* **5,** No. 1, 79-102 (1976).

Rotational transitions; silicon sulfide; spectra; interstellar molecules; microwave spectra; radio astronomy; *JPCRD* **5,** No. 4, 1147-1156 (1976).

Rotation-vibration spectra; semiclassical *S*-matrix; spectral line broadening; *ab initio* potentials; atom-molecule interactions; curved classical trajectories; HCl, CO, CO_2 with He, Ar; *16528.*

Rotatory lattice modes; *n*-alkanes; polyethylene; Raman spectroscopy; *16218.*

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Round robin tests; seacoast atmosphere; standard; stress-corrosion; 3.5 percent NaCl; 7XXX aluminum alloys; Aluminum Association; ASTM; industrial atmosphere; *16656.*

Round-robin experiments; trace element analysis; accuracy; activation analysis; air filter analysis; analytical quality control; atomic absorption spectrometry; environmental analysis; fresh water analysis; intercomparisons; precision; *SP422,* pp. 189-197 (Aug. 1976).

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Rubber elasticity; statistical theory of rubber elasticity; swelling of rubber network; cross-linking of rubber; dicumyl peroxide; elasticity theory of rubber; entanglements in rubber; gel point; modulus of rubber; *J. Res.* **80A** No. 3, 451-463 (1976).

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Rubidium frequency standard; time comparison; atomic clocks; frequency stability; portable clocks; *16489.*

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Ruthenium; ellipsometry; optical constants; *16467.*

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Rutherford backscattering; scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; shear test; sheet resistors; silicon; silicon on sapphire; spreading resistance; test patterns; *SP400-19.*

Rutherford backscattering; SCANIIR; secondary ion mass spectroscopy; semiconductor devices; silicon; surface analy-

sis; x-ray photoelectron spectroscopy; Auger spectroscopy; depth profiles; electron beam induced imaging; ESCA; insulator films; *SP400-23*.

Rutherford backscattering; secondary ion mass spectroscopy; silicon; silicon dioxide; surface analysis; x-ray photoelectron spectroscopy; Auger electron spectroscopy; depth impurity profiling; ion implantation; ion sputtering; microelectronic materials; *15739*.

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Rydberg series; absorption spectrum; identification atlas; nitric oxide; *JPCRD* **5**, No. 2, 309-318 (1976).

Rydberg states; ammonia; appearance potential; autoionization; deuterated species; enthalpy of formation; ionization potential; NH_2^+; OH^+; photoionization; predissociation; *16539*.

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Safeguards; traceability; calibration; measurement; nondestructive assay; nuclear; *16414*..

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Safety; glare; lighting; perceptual/motor; psychomotor; *NBS-GCR-75-45*.

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Safety; shoring; standards; building; codes; concrete; construction; falsework; formwork; loads; reshoring; *BSS80*.

Safety; slush hydrogen; superconducting; a.c. power; cryoresistive; energy transmission economics; helium; hydrogen energy; liquid hydrogen; liquid nitrogen; power transmission cables; *16629*.

Safety; statistical analysis; structural engineering; failure; probability theory; random process; *SP444*, pp. IV-1—IV-15 (Apr. 1976).

Safety; structural testing; bicycle; consumer safety; regulations; *NBSIR 75-913*.

Safety; surveys; buildings; fires; loads; *16087*.

Safety; technical analysis; temperature; air flow rate; electrical, mechanical and thermal hazards; hair dryer/stylers; heat flux; *NBSIR 76-1112*.

Safety; test methods; head injury; helmets; math model; protective headgear; *NBSIR 76-1107*.

Safety; testing; bicycles; braking; consumer safety; handbrake; *NBSIR 75-755*.

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Safety standards; failure prevention; mechanical failure; mechanical malfunction; quality assurance; reactor systems and components; *SP423*, pp. 143-151 (Apr. 1976).
Safety standards; transportation safety; effects of mechanical failure on environment; failure prevention; government action; mechanical failure; *SP423*, pp. 153-163 (Apr. 1976).
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Sample; software management; survey; ADP; COBOL; Federal ADP installations; Federal Standard COBOL; impact evaluation; *NBSIR 76-1100*.
Sample characteristics; straylight; wavelength accuracy; bandwidth; calibration; errors in spectrophotometry; interferences; multiple reflections; photometric linearity; polarization; *J. Res.* **80A** No. 4, 609-624 (1976).
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Sample preparation; toxic metals; trace determination; aquatic insects; atomic absorption; clean room; fish; mini-computer; *SP422*, pp. 627-632 (Aug. 1976).
Sample preparation; trace element analysis; accuracy and precision; comparison of trace analytical methods; contamination; rocks and ores; *SP422*, pp. 773-790 (Aug. 1976).
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Sample stability; surface water analysis; filtration losses; metallic ions; pollution monitoring;rainwater analysis; *SP422*, pp. 633-648 (Aug. 1976).
Sample storage; sampling; accuracy; analytical chemistry; contamination; errors; natural water; *SP422*, pp. 805-836 (Aug. 1976).
Sampling; accuracy; analytical chemistry; contamination; errors; natural water; sample storage; *SP422*, pp. 805-836 (Aug. 1976).
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Sampling; trace analysis; water sampling; contamination; geological sample; rocks and minerals; sample preparation; *SP422*, pp. 285-297 (Aug. 1976).
Sampling; trace elements; chemical analysis; environmental samples; long-term storage; microbiologicals; organics; pesticides; radionuclides; sample handling; *TN929*.
Sampling; water; analysis; carbon; crud; filtration; pressurized water reactors; primary coolant; *SP422*, pp. 429-438 (Aug. 1976).
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Sampling air; accuracy and precision; air; air particulates; air pollution; analysis of air; atmosphere; gaseous pollutants; *SP422*, pp. 311-320 (Aug. 1976).
Sampling and sample handling; accuracy and precision; activation analysis; analytical design; irradiation procedures; radioactivity detection systems; radiochemical separations; *SP422*, pp. 1143-1155 (Aug. 1976).
Sampling constants; standard biotite; biotite stoichiometry; geochemical standards; geochronological standards; K-Ar dating; sampling a biotite; *SP422*, pp. 401-419 (Aug. 1976).
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Sampling test; drop ball test; impact resistance; ophthalmic lens; proof testing; research associate program; *NBSIR 76-996*.

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Sand motion under waves; beach accretion; coastal processes; offshore zone; oscillatory water tunnel; permeability effect on sand transport; ripples, sand; *15793*.

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Sapphire surfaces; silicon films; specular reflection; differential reflection; epitaxial semiconductor devices; Kramers-Kronig relation; multiple reflection; *NBS-GCR-76-61*.

SASO; Saudi Arabia; standardization; tentative standards; building codes; industrialization; less-developed country; *NBSIR 75-976*.

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Saturated liquid; specific heat; vapor; constant volume; ethane; heat capacity; liquid; *J. Res.* **80A** Nos. 5 and 6, 739-759 (1976).

Saturated liquid; table; density; experimental; magnetic suspension densimeter; normal butane; *16646*.

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Saudi Arabia; standardization; tentative standards; building codes; industrialization; less-developed country; SASO; *NBSIR 75-976*.

Sawing; silicon; standard; weighing; density; etching; grinding; *NBSIR 76-1019*.

SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital; capital market imperfections; federal technology policy; *NBS-GCR-ETIP 76-08*.

SBIC's; securities and tax regulation; small firm finances; technological change; technology subsidies; venture capital; capital market imperfections; federal technology policy; *NBS-GCR-ETIP 76-12*.

Scaled equation; steam; critical density; critical exponents; critical pressure; critical region; critical temperature; equation of state; linear model; *15730*.

Scaling; steam; universality; critical exponents; critical region; homogeneity; polar fluids; *15733*.

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Scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; shear test; sheet resistors; silicon; silicon on sapphire; spreading resistance; test patterns; thermal resistance; *SP400-19*.

Scanning electron microscope; scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; silicon; silicon dioxide; silicon on sapphire; spreading resistance; test patterns; thermally stimulated current; *SP400-25*.

Scanning electron microscope; iron-silicon transformer steel; magnetic contrast; magnetic domain images; magnetic domains; Monte Carlo electron trajectory calculations; *SP460*, pp. 151-164 (Dec. 1976).

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Scanning electron microscope; silicon steel; transformer steel; backscattered electrons; domain walls; magnetic domains; *15921*.

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Scanning electron microscopy; electron beam damage; electron beam energy deposition; ionizing radiation; microelectronic devices; *15963*.

Scanning electron microscopy; semiconductor devices; device inspection; electron-beam-induced current; microelectronics; *p-n* junctions; *16449*.

Scanning electron microscopy; thin film analysis; electron probe microanalysis; electron-solid interactions, magnetic domains;

Monte Carlo electron trajectory calculations; particle analysis; *SP460*.

Scanning electron microscopy; x-ray microanalysis; electron probe microanalysis; electron scattering; electron-specimen interactions; Monte Carlo electron trajectory calculations; *SP460*, pp. 5-14 (Dec. 1976).

Scanning electron microscopy; secondary electrons; x rays; backscattered electrons; electron probe microanalysis; Monte Carlo electron trajectory simulation; *SP460*, pp. 15-44 (Dec. 1976).

Scanning electron microscopy; x-ray generation; electron microscopy; electron probe microanalysis; electron-specimen interactions; Monte Carlo electron trajectory simulation; *SP460*, pp. 45-60 (Dec. 1976).

Scanning electron microscopy; x-ray microanalysis; electron energy loss; Landau electron deceleration theory; microanalysis; Monte Carlo electron trajectory calculations; *SP460*, pp. 61-96 (Dec. 1976).

Scanning electron microscopy; thin films; x-ray analysis; electron probe microanalysis; Monte Carlo electron trajectory calculations; nuclear backscattering analysis; *SP460*, pp. 129-138 (Dec. 1976).

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Scanning electron microscopy; cement; compressive strength; flexural strength; fracture mechanics; polymer impregnated cement; polymer impregnated mortar; porosity; *BSS83*.

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Scanning low energy electron probe; semiconductor devices; semiconductor materials; semiconductor process control; shear test; sheet resistors; silicon; silicon on sapphire; spreading resistance; test patterns; thermal sistance; thermal response; transistors; *SP400-19*.

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Scattered light; surface absorption; alkali-halide; KCl; laser windows; optical figure; polishing; *SP435*, pp. 20-28 (Apr. 1976).

Scattered light; surface figure; blur circle; circular diffraction grating; diamond-turned mirrors; diffraction pattern; machine cusp; *SP435*, pp. 57-65 (Apr. 1976).

Scattering; albedo; collimation; dosimetry; ion chambers; n-γ dosimetry; neutrons; *SP456*, pp. 335-341 (Nov. 1976).

Scattering; scattering theory; surface roughness; transmittance; bibliography; emittance; heat transfer; measurement techniques; periodic surfaces; polarization; random surfaces; reflectance; reflectance of coherent radiation; *J. Res.* **80A** No. 2, 207-220 (1976).

Scattering; spectrophotometry; translucency; transmittance; Vitrolite glass; blurring effect; edge loss; error analysis; flux loss; plastics; reflectance; *TN594-12*.

Scattering; spin-polarization; electron; experiment; LEED; multi-photon; photoionization; review; *15900*.

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Standard; detectors; germanium; ion chamber; liquid scintillation; sodium iodide; *SP456*, pp. 77-82 (Nov. 1976).

Standard; dimensional; gage; instrument; laser; length; machine; measurements; *NBSIR 75-926.*

Standard; γ radiation; γ response; calibration; exposure rate; geometry; instrument; ion chamber; roentgen; *SP456*, pp. 59-63 (Nov. 1976).

Standard; standard test; thermal performance; thermal storage; solar collector; solar energy; solar radiation; *TN899.*

Standard; stress-corrosion; 3.5 percent NaCl; 7XXX aluminum alloys; Aluminum Association; ASTM; industrial atmosphere; round robin tests; seacoast atmosphere; *16656.*

Standard; trace elements; accuracy; Atomic Absorption Spectrometry; Caribbean; precision; Puerto Rico; replicates; sediments; *SP422*, pp. 1089-1102 (Aug. 1976).

Standard; weighing; density; etching; grinding; sawing; silicon; *NBSIR 76-1019.*

Standard; x ray; alpha particle; beta particle; gamma-ray; radioactivity; sediment; *15933.*

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Standard; x-ray diffraction; crystal structure; integrated intensities; lattice constants; peak intensities; powder patterns; reference intensities; *Monogr. 25, Section 13.*
Standard materials; trace element analysis; errors of analysis; homogenization; neutron activation analysis; sample preparation; *SP422*, pp. 1293-1304 (Aug. 1976).
Standard biotite; biotite stoichiometry; geochemical standards; geochronological standards; K-Ar dating; sampling a biotite; sampling constants; *SP422*, pp. 401-419 (Aug. 1976).
Standard cell; voltage reference; cryogenic; Josephson junction; *16377.*
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Standard cells; U.S. legal volt; volt; voltage measurement; electrical standards; *16268.*
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Standard deviation; uncertainty; calibration; diameter; gravitational bending; interferometry; least squares line; linear model; optical flat; profile; *NBSIR 75-975.*
Standard deviation; uncertainty; autocollimator; calibration; constant deviation prism; geometrical model; optical square; pentaprism; reflection; refraction; *NBSIR 76-993.*
Standard enthalpy of formation; vibrational fundamentals; chlorofluorpmethanes; ideal gas thermodynamic functions; principal moments of inertia; *JPCRD* **5,** No. 3, 571-580 (1976).
Standard frequencies; television color subcarrier; time calibration; time signals; broadcast of standard frequencies; frequency calibration; high frequency; low frequency; *SP432.*
Standard materials; trace elements; accuracy; biological materials; data interpretation; *SP422*, pp. 65-77 (Aug. 1976).
Standard reference data; thermochemical tables; enthalpy; entropy; Gibbs energy; heat capacity; potassium compounds; rubidium compounds; sodium compounds; *NBSIR 76-1034.*
Standard reference data system; computer age; data system; materials research; measurement challenge; science and technology; sea of data; *DIM/NBS* **60/Suppl.,** Anniversary Issue, 1-32 (1976).
Standard reference material; steel; alpha particles; boron; ion microprobe mass analyzer; nuclear track technique; *15789.*
Standard reference material; systematic errors; accuracy; accurate measurement system; precision; reference methods; *SP422*, pp. 41-63 (Aug. 1976).
Standard reference material; statistics; syndrome; accuracy; analytical chemistry; *SP422*, pp. 123-126 (Aug. 1976).
Standard reference materials; transmittance characteristics; ultraviolet-visible filters; evaporated metal-on-quartz; filters, transmittance; neutral filters; *J. Res.* **80A** No. 4, 637-641 (1976).
Standard reference materials; thermophysical properties symposium; waste heat; computer; consumer; drugs; electrical pulses; environmental standards; friction measurement; lead poisoning; LNG data; optical; *DIM/NBS* **60,** No. 9, 1-24 (1976).
Standard reference materials; trace elements; analytical methods; coal; environmental samples; environmental standards; fly ash; instrumental neutron activation analysis (INAA); instrumental photon activation analysis (IPAA); *SP422*, pp. 211-223 (Aug. 1976).
Standard Reference Materials; atomic absorption spectrometry; nonflame graphite furnace; sensitivity *vs.* precision and accuracy; *SP422*, pp. 1045-1051 (Aug. 1976).
Standard reference materials; coal; energy; fuel; graphite; hydrocarbons; metering; methane; natural gas; petroleum; physical properties; *SP434.*
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Standard test methods; aging test; building elements and materials; degradation factors; durability; property measurement test; *NBSIR 75-955.*
Standardization; coincidence counting; gamma rays; ground state decay; radioactivity; selenium-75; *15846.*
Standardization; tentative standards; building codes; industrialization; less-developed country; SASO; Saudi Arabia; *NBSIR 75-976.*
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Standardization; testing facilities; Bolivia; measurements; quality control; *NBSIR 76-1099.*
Standardization; tissue characterization; ultrasound; blood; cross-section; diagnosis; scattering; *SP453*, pp. 29-47 (Oct. 1976).
Standardization; ^{129}I; beta; coincidence counting; gamma; radioactivity; *16259.*
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Standards; calibrations; environment; measurements; medical; radiation; *SP456.*
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Standards; computer techniques; construction; enforcement process; housing; hurricane Agnes; mobile home parks; mobile homes; performance data; regulatory process; *NBSIR 76-1058.*
Standards; dynamic force; economic; force; metrication; national measurement system; *NBSIR 75-929.*
Standards; energy; legal; regulatory; *SP403,* pp. 225-235 (June 1976).
Standards; engine pumper; fire vehicle; ladder truck; maintenance; replacement; specifications; *TN891.*
Standards; environment; gamma-ray measurements; Ge(Li) detectors; radioactivity; *SP456,* pp. 173-179 (Nov. 1976).
Standards; fuel; materials accountability; measurements; nuclear; safeguards; *16481.*
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Standards; state regulation; building codes; certification; compliance assurance; evaluation; inspection; manufactured building; model documents; NCSBCS; *BSS87.*
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Standards; steel; thermal; thermodynamics; automobile; break-even analysis; conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; *SP403.*
Standards; steel; titanium; transducer calibration; ultrasonic reference blocks; acoustic emission; aluminum; fatigue cracks; flat bottomed holes; *16252.*
Standards; stiffness; structural stability; walls; brick; buckling; composite walls; compressive strength; concrete block; constitutive relations; flexural strength; masonry; masonry walls; mortar; slenderness ratio; *BSS73.*
Standards; structural design; earthquake; housing; performance specification; prefabricated dwelling; *SP444,* pp. IV-55—IV-69 (Apr. 1976).
Standards; sulfur dioxide; carbon monoxide; hydrocarbons; measurement; nitrogen dioxide; particulate matter; photochemical oxidants; *16121.*
Standards; supermarket automation; weights and measures; calibration; communication; consumers; grain moisture measurement; laws and regulations; measurement; metric; packaging and labeling; police radar equipment; *SP442.*
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Standards; system engineering; building codes; computer model; decision theory; networks; specifications; *NBS-GCR-76-55.*
Standards; systems engineering; building codes; computer program; decision theory; networks; specifications; *NBS-GCR-76-56.*
Standards; systems engineering; building codes; computer program; decision theory; FORTRAN; logic design; networks; specifications; *NBS-GCR-76-57.*
Standards; technical bases; building research; building technology; codes; criteria; project summaries; *SP446.*
Standards; technology assessment; user experience; auditing; cost/benefit analysis; data base; data base management; DBMS; government regulation; management objectives; privacy; security; *SP451.*
Standards; teletypewriters; coding; interfaces; modems; signal processing; *NBS-GCR-74-30.*
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Standards; test methods; watthour meters; code; definitions; demand meters; electricity metering; performance requirements; *15829.*
Standards; thermal storage; solar buildings; solar collectors; solar domestic hot water systems; solar heating; *NBSIR 76-1059.*
Standards; thermometry; data; International Practical Temperature Scale; measurements; National Measurement System; *NBSIR 75-932.*
Standards; traceability; assurance; measurement; radioactivity; radiopharmaceutical; *SP456,* pp. 71-76 (Nov. 1976).
Standards; units of measurement; weights; history of measurement standards; measures; metric system; *SP447.*
Standards; user groups; computers; data base management; governments; management information systems; public services; security; *15923.*
Standards, bicycle safety; test method, bicycle; bicycle brakes; brakes, bicycle; dynamics, bicycle; error analysis; friction, tire/pavement; kinetics, bicycle; measurements, bicycle braking; pitchover; *NBSIR 75-786.*
Standards calibration; barium sulfate; diffuse reflectance spectra; magnesium oxide; opal glass; radiant flux; reflectance standards; *J. Res.* **80A** No. 4, 585-595 (1976).
Standards conformance; COBOL; COBOL coding form; Federal Information Processing Standard; Federal Standard COBOL; software; *FIPS PUB 44.*
Standards development; technological change; administrative experiment; American National Standards Institute; Experimental Technology Incentives Program; Nuclear Regulatory Commission; *NBS-GCR-ETIP 76-16.*

Standards for safety; Government participation; refrigeration safety standards; safety of appliances; *15890.*

Standards laboratories; telephone industry and specialized carriers; time and frequency; time scales; users of NBS radio broadcasts; atomic frequency standards; aviation industry; electric power industry; National Measurement System, position location; *SP445-1.*

Standards laboratory; synchrotron; building collapse; corrosion; energy; environmental; frequency standards; hearing aids; high-rise buildings; metals; radiation safety; *DIM/NBS* **60,** No. 5, 1-24 (1976).

Standards organization; acoustics; noise; rating scheme; sound; *SP386, 1976 Edition.*

Standards organization; test methods; plastics standardization; specifications; standards; *16106.*

Standards, uses of radiation; ionizing radiation; measurements; *SP456,* pp. 13-24 (Nov. 1976).

Standing waves; electric fields; laser damage; oblique incidence; *SP462,* pp. 25-28 (Dec. 1976).

Standing-wave fields; thin films; two-photon absorption; damage thresholds; electron avalanche; picosecond pulses; refractory oxides; *SP462,* pp. 292-300 (Dec. 1976).

Standing-wave patterns; damage thresholds; dielectric thin films; electric fields; electron-gun evaporation; picosecond pulses; rf sputtering; *SP435,* pp. 254-271 (Apr. 1976).

Standing-waves; dielectric films; electric fields; laser damage; optical coatings; *SP462,* pp. 301-309 (Dec. 1976).

Stark broadening; Stark shifts; Stark widths; nitrogen; plasma line broadening; spectral lines; *16406.*

Stark broadening; width; experimental; neutral atom; review; shift; *JPCRD* **5,** No. 2, 209-258 (1976).

Stark broadening parameters; Stark shifts; Stark widths; critically evaluated data; experimental; ionized spectra; *JPCRD* **5,** No. 2, 259-308 (1976).

Stark effect; atomic hydrogen; Balmer alpha; beam foil; crossed beams; electrons; excitation; optical spectroscopy; *15891.*

Stark effect; carbonyl sulfide; dipole moments; infrared; lasers; spectra; spectroscopy; *16181.*

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Stark spectrum; surface excitons; bulk excitons; electron loss spectroscopy; ionic crystals; Madelung potential; Mg^{+}; Mg^{2+}; MgO; *SP455,* pp. 59-65 (Nov. 1976).

Stark widths; critically evaluated data; experimental; ionized spectra; Stark broadening parameters; Stark shifts; *JPCRD* **5,** No. 2, 259-308 (1976).

Stark widths; nitrogen; plasma line broadening; spectral lines; Stark broadening; Stark shifts; *16406.*

Stars: chromospheres; line formation; radiative transfer; *16052.*

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State; architecture; buildings; design; energy; legislation; solar; *NBSIR 76-1082.*

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State law; architectural glazing; codes; Consumer Product Safety Committee; Consumer Safety Glazing Committee; glazing; impact tests; safety glazing; standards; *NBSIR 76-1109.*

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State regulations; building codes; factory-built housing; industrialized building; inspection; manufactured building; model codes; model documents; NCSBCS; on-site construction; prefabricated construction; standards; state-local relationship; *NBS-GCR-74-27.*

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State-of-the-art reviews; acceptability; coding; costs; data transmission systems; decisionmaking; economics; errors; information theory; input-output devices; interfaces; malfunctions; man-machine systems; remote control systems; systems engineering; *NBS-GCR-74-29.*

State-of-the-art study; automatic data processing; building codes; building regulations; computer applications; computers; enforcement; evaluation; information systems; microfilm; microform; *NBS-GCR-74-26.*

States; abstract; compromise; ineffectiveness; measurements; radiation; regulations; *SP456,* pp. 31-36 (Nov. 1976).

States; building codes; cities; health and safety; historic preservation; *TN918.*

Static; vibration; deflection; dynamic; floor systems; human responses; performance criteria; serviceability; *TN900.*

Static analysis; transforms; execution; execution monitoring; FORTRAN analysis; source code instrumenting; *15918.*

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Static loads; stiffness; structural safety; design; dynamic loads; guardrails; industrial accidents; nonstructural safety; occupational hazards; performance standard; personnel railings; personnel safety; *NBSIR 76-1131.*

Static potential; vibrational excitation; close-coupling calculations; crossed beams; cross sections; differential cross sections; electron scattering; inelastic scattering; nitrogen molecules; polarization potential; scattering; *16533.*

Static pressure; weatherproof pressure probe; wind field pressure measurements; ambient pressure probe; omnidirectional pressure probe; pressure probe shroud; *U.S. Patent 3,950,995.*

Stationary models; flicker noise; frequency; frequency stability; oscillators; phase noise; *TN683.*

Statistical; background; critical level; detection limit; determination limit; less-than level; minimum detectable activity; *SP456,* pp. 169-172 (Nov. 1976).

Statistical analysis; steam; universality; air constituents; critical

region parameters; ethylene; heavy noble gases; helium; linear model; methane; NBS equation; scaling laws; *JPCRD* **5**, No. 1, 1-52 (1976).
Statistical analysis; storms; structural engineering; wind pressure; wind speed; buildings (codes); hurricanes; probability distribution functions; reliability; risk; *16545*.
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Statistical control processes; temperature; acoustic calibrators; A-weighting; barometric pressure; crest factor; ground cover; humidity; instrumentation; microphones; sound level meters; *TN931*.
Statistical education in the United States; statistical tolerance limits; U.S. Army programs in statistics; U.S. Government, services to; Wilks award; Wilks, S. S; *Annals of Mathematical Statistics;* bibliography; distribution-free methods; *16114*.
Statistical methods; zinc; atomic absorption; cadmium; copper; lead; manganese; sensitivity; spectrophotometry; *SP422*, pp. 1023-1033 (Aug. 1976).
Statistical models; absolute absorptivities; continuum models; diffuse reflectance; radiative transfer; reflectance spectra; scattering coefficients; *J. Res.* **80A** No. 4, 567-583 (1976).
Statistical techniques; Youden plot; Youden squares; Youden, W. J; calibration designs; chain blocks; collaborative tests; diagnostic tests, index for rating; experiment design, statistical; graphical diagnosis; interlaboratory tests; randomization, constrained; *16115*.
Statistical theory of rubber elasticity; swelling of rubber network; cross-linking of rubber; dicumyl peroxide; elasticity theory of rubber; entanglements in rubber; gel point; modulus of rubber; *J. Res.* **80A** No. 3, 451-463 (1976).
Statistical tolerance limits; U.S. Army programs in statistics; U.S. Government, services to; Wilks award; Wilks, S. S; *Annals of Mathematical Statistics;* bibliography; distribution-free methods; educational testing; mathematical statistics; *16114*.
Statistics; analytical chemistry; curve fitting; data reduction; feature selection; multivariate analysis; optimization techniques; pattern recognition; signal processing; spectral resolution; *15964*.
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Statistics; strength; crack propagation; error analysis; failure prediction; failure prevention; fracture; *NBSIR 75-952*.
Statistics; syndrome; accuracy; analytical chemistry; standard reference material; *SP422*, pp. 123-126 (Aug. 1976).
Statistics; tolerance limits; noncentral *t*-distribution; normal distribution; *J. Res.* **80B** No. 3, 343-346 (1976).
Statistics; uncertainties; crystallographic data; errors; probability plots; residuals; *NBSIR 76-1102*.
Steady-state overvoltages; copper electrodes; interfacial resistance; metal-metal oxide electrodes; oxygen transport; *SP455*, pp. 351-358 (Nov. 1976).
Steady-state x rays; detector calibrations; fluorescence x-ray sources; K x-ray sources; pulsed x rays; radiographic imaging; *SP456*, pp. 41-45 (Nov. 1976).
Steam; critical density; critical exponents; critical pressure; critical region; critical temperature; equation of state; linear model; scaled equation; *15730*.
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Steam; universality; critical exponents; critical region; homogeneity; polar fluids; scaling; *15733*.
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Steel; alpha particles; boron; ion microprobe mass analyzer; nuclear track technique; standard reference material; *15789*.
Steel; energy; forecast; industry; iron; *SP403*, pp. 121-152 (June 1976).
Steel; structural mechanics; uncertainty; creep; fire endurance; fire tests; reinforced concrete; sensitivity analysis; *BSS76*.
Steel; thermal; thermodynamics; automobile; break-even analysis; conservation; cooling; economics; energy; environment; fuel; heating; imports; industry; management; manufacturing; paper; petroleum; resources; standards; *SP403*.
Steel; titanium; transducer calibration; ultrasonic reference blocks; acoustic emission; aluminum; fatigue cracks; flat bottomed holes; standards; *16252*.
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Steel; welding; alloying; inclusions; low temperature; rolling; ships; *16145*.
Steel reinforcing bars; bridge decks; chloride ions; corrosion; deicing salts; epoxy coatings; organic coatings; *16189*.
Steel ultrasonic standards; titanium ultrasonic standards; ultrasonics; aluminum ultrasonic standards; ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; metallurgical variables; *NBSIR 76-984*.
Stellar; ultraviolet; absorption; B-stars; C IV; O-stars; Si IV; spectra; *16271*.
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Step height; interferometer; polarization; *16382*.
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Stereometry; stereoscopy; stochastic models; structures; three-dimensional reconstruction; stereology; *SP431*.
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Stirling numbers; bell numbers; branching theorem; Clebsch-

Gordon series; irreducible character; matrix functions; multiple transitivity; permutation group; *J. Res.* **80B** No. 2, 265-268 (1976).

Stirling numbers; binomial coefficients; modular computation; *J. Res.* **80B** No. 1, 99-171 (1976).

Stirred liquid comparison bath; temperature scale; calibration; emergent stem; liquid-in-glass thermometer; reference point; *Monogr. 150.*

Stirred solution; crystallization; cylindrite; drawing of swollen polymer solid; epitaxial overgrowth; extrusion; hard elastomer; nucleation; oriented melt; rheological unites; row nucleus; shishkebab; sonicated solution; spinning; *16274.*

Stochastic models; structures; three-dimensional reconstruction; stereology; stereometry; stereoscopy; *SP431.*

Stochastic Weber problem; always convergent algorithms; exponentially distributed points; facility location; location theory; normally distributed points; numerical analysis; optimization; *J. Res.* **80B** No. 1, 53-73 (1976).

Stoichiometry; transmission electron microscopy; vapor deposition; cadmium telluride; growth kinetics; mechanical properties; microstructure; *SP462*, pp. 100-118 (Dec. 1976).

Stoichiometry; whitlockite; β-tricalcium; calcification; calcium; dicalcium phosphate; octacalcium phosphate; pyrolysis; pyrophosphate; *15996.*

Stopping-power ratios; calorimeter; dose/ionization conversion; dosimetry; electrons; ionization chamber; *SP456*, pp. 307-312 (Nov. 1976).

Storage containers; adsorption losses; biological systems; chromium; stability; *SP422*, pp. 611-619 (Aug. 1976).

Storage effects; 2,4-dichlorophenol; 2,4-dichlorophenoxyacetic acid; gas chromatography; potatoes; residues, dissipation of; residues, in potatoes; residues, metabolic; residues, total; residues, volatilization; *SP422*, pp. 737-745 (Aug. 1976).

Storage of clinical samples; accuracy and precision; analysis of body fluids; clinical analysis; clinical chemistry; clinical sampling; enzyme analysis; *SP422*, pp. 353-361 (Aug. 1976).

Storm; structural engineering; technological aid; earthquake; Japan; natural disaster; *SP444*, pp. VI-25—VI-31 (Apr. 1976).

Storms; structural engineering; wind pressure; wind speed; buildings (codes); hurricanes; probability distribution functions; reliability; risk; statistical analysis; *16545.*

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Strategy; theory of games; inspection; mathematical model; regulation; *J. Res.* **80B** No. 2, 189-236 (1976).

Stratified flow, internal waves, buoyant flows; fluid dynamics; fundamental solution, intitial value problem; partial differential equations; *J. Res.* **80B** No. 1, 79-88 (1976).

Stratified fluids; waves in fluids; buoyant flows; geophysical fluid flows; inertial waves; internal waves; rotating fluids; *J. Res.* **80B** No. 3, 353-402 (1976).

Stratosphere; chemical kinetics; free radicals; measurement; *16130.*

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Stratospheric chemistry; atmospheric pollution; chlorine nitrate; dipole moment; microwave spectrum; ozone depletion; rotational constants; *16584.*

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Stray light; wavelength scale; errors in spectrophotometry; photometric scale; slit width; spectral transmission; spectrophotometer standards; *J. Res.* **80A** No. 4, 625-630 (1976).

Stray light; xenon-mercury, arc lamp; arsenic; atomic absorption; atomic spectrometry; background, correction; nonflame, atomization; *15894.*

Straylight; wavelength accuracy; bandwidth; calibration; errors in spectrophotometry; interferences; multiple reflections; photometric linearity; polarization; sample characteristics; *J. Res.* **80A** No. 4, 609-624 (1976).

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Surfaces; textiles; edges; fabric construction; fabric flammability; fire spread; flame spread; flame spread rate; *NBS-GCR-75-34.*

Surfaces; tungsten; ultraviolet photoemission; valence band; virgin states; α states; β states; adsorption; carbon; carbon monoxide; chemical bonding; chemisorption; density dependent transitions; desorption; dissociative adsorption; electronic states; hydrogen; *16419.*

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Surfaces; x-ray photoemission; chemisorption; ESCA; field emission; photoemission; *16454.*

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Surgical implants; cardiac pacemaker; data banks; failure analysis; failure modes; hermeticity; hybrid devices; leak testing; measurement technology; microelectronics; MOS devices; process control; reliability; semiconductor devices; *SP400-28.*

Surgical implants; testing; thermal transients; architectural heritage; fire; guardrail; high-capacity; mathematics; mercury; performance standard; pressure transducers; SRM; *DIM/NBS* **60**, No. 8, 1-24 (1976).

Surrogate specimens; trace elements; accuracy and precision; clinical chemistry; quality control; *SP422*, pp. 35-40 (Aug. 1976).

Survey; ADP; COBOL; Federal ADP installations; Federal Standard COBOL; impact evaluation; sample; software management; *NBSIR 76-1100.*

Survey; ultraviolet; detectors; NBS; radiometry; sources; standards; *SP456*, pp. 107-110 (Nov. 1976).

Survey; water hardness; corrosion; corrosion control; metallic piping; nondestructive evaluation; *NBSIR 75-923.*

Survey of automatic techniques; swept frequency measurements; Wheatstone Bridge; automatic network analyzers; computer-controlled measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; rotating probe devices; slotted lines; *Monogr. 151.*

Survey of clocks; accuracy; atomic clocks; clocks; crystal oscillator; frequency standards; stability; *15719.*

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Suspension; acidity; contact; decantate; electrode; error; extract; paper; pH; *NBSIR 75-915.*

Swelling of rubber network; cross-linking of rubber; dicumyl peroxide; elasticity theory of rubber; entanglements in rubber; gel point; modulus of rubber; molecular interpretation of rubber elasticity; rubber elasticity; *J. Res.* **80A** No. 3, 451-463 (1976).

Swept frequency; time delay spectrometry; tissue; transmission; velocity; attenuation; phase; *SP453*, pp. 81-95 (Oct. 1976).

Swept frequency measurements; Wheatstone Bridge; automatic network analyzers; computer-controlled measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; rotating probe devices; slotted lines; survey of automatic techniques; *Monogr. 151.*

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Symmetries; ψ particles; χ particles; angular distributions; gamma-gamma correlations; quark models; *15962.*

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Symposium; critical current; mechanical properties; stress effects; superconductors; *16636.*

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Synchrotron; building collapse; corrosion; energy; environmental; frequency standards; hearing aids; high-rise buildings; metals; radiation safety; standards laboratory; *DIM/NBS* **60,** No. 5, 1-24 (1976).

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Syndrome; accuracy; analytical chemistry; standard reference material; statistics; *SP422,* pp. 123-126 (Aug. 1976).

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Synthetic implants; adsorption; blood protein; bound fraction; ellipsometry; implants; polymer adsorption; protein adsorption; *NBSIR 75-667.*

Synthetic implants; adsorption; blood protein; bound fraction; ellipsometry; implants; polymer adsorption; protein adsorption; *NBSIR 76-1017.*

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Systematic error; Youden plot; analytical performance; between-run; calibration; precision; quality control; *SP422,* pp. 141-150 (Aug. 1976).

Systematic errors; accuracy; accurate measurement system; precision; reference methods; standard reference material; *SP422,* pp. 41-63 (Aug. 1976).

Systematic errors; trace analysis; accuracy; activation analysis; analytical chemistry; charged particle activation analysis; cross sections; excitation functions; fast neutron activation analysis; fast particle activation analysis; *SP422,* pp. 1189-1214 (Aug. 1976).

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Systems; attitudes; conservation; energy; industrial; *SP403,* pp. 113-117 (June 1976).

Systems analysis; design criteria; fire hazards; fire losses; fire reporting; fire safety; information systems; National Fire Data System; specifications; state governments; *NBS-GCR-73-5.*

Systems analysis; urban problems; operations research; *16119.*

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Taxonomy of integrity flaws; UNIVAC 1100 Series OS; BBN-TENEX; IBM OS/360; operating system security; security flaws; software security; *NBSIR 76-1041.*

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Tearing; vibratory apparatus; adhesion; cavitation; coatings; design charts; elastomers; erosion; Hopkinson pressure bar apparatus; impedances; mismatching; stress wave interactions; substrates; *SP452,* pp. 120-123 (Sept. 1976).

Technical aid; adobe; cane; earthquake; housing; Peru; *SP444,* pp. VI-16—VI-24 (Apr. 1976).

Technical aid; volcanoes; field observation; Indonesia; Japan; *SP444,* pp. VI-1—VI-15 (Apr. 1976).

Technical analysis; temperature; air flow rate; electrical, mechanical and thermal hazards; hair dryer/stylers; heat flux; safety; *NBSIR 76-1112.*

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Technological change; decisionmaking; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; policies; private sector; R&D; *NBS-GCR-ETIP 76-04.*

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Technological innovation; bibliography, technological innovation; innovation, technological; *NBS-GCR-ETIP 73-03.*

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Technology; demonstration projects; Experimental Technology Incentives Program; federal funding of civilian R&D; federal policies; guidelines; policies; R&D; technological change; *NBS-GCR-ETIP 76-05.*

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Technology assessment; user experience; auditing; cost/benefit analysis; data base; data base management; DBMS; government regulation; management objectives; privacy; security; standards; *SP451.*

Technology for security and privacy; computer security; information handling; privacy; safeguards for security and privacy; *16439.*

Technology incentives; energy conservation; ETIP; government procurement policy; noise reduction; performance specification; *NBS-GCR-ETIP 73-05.*

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Telecommunication; common carriers; computer networks; interfaces; modems; *NBS-GCR-74-31.*

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Temperature coefficient of refractive index; calcium fluoride; refractive index; *SP462,* pp. 64-68 (Dec. 1976).

Temperature dependence; wavelength dependence; multilayer dielectric mirror; optical absorptance; reflectance; scattering; *SP435,* pp. 230-235 (Apr. 1976).

Temperature drift; thermodynamic properties; glass transition; heat capacity; high molecular weight linear polyethylene; polyethylene; *J. Res.* **80A** No. 1, 51-57 (1976).

Temperature effects; absorption: extinction coefficients; N_2O_4; NO_2; spectra; *J. Res.* **80A** No. 2, 143-166 (1976).

Temperature effects; trace elements; zinc; atomic absorption spectrophotometry; calcium; container effects; copper; magnesium; potassium; serum minerals; serum storage effects; sodium; *SP422,* pp. 575-591 (Aug. 1976).

Temperature gradient; thermal gradient; thermocouple; thermoelectric stability; aging; calibration change; gradient; high temperature (700 to 2000 °C); iridium; iridium-rhodium alloy; noble-metal thermocouple; oxidation; platinum; platinum-rhodium alloy; *16158.*

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Temperature standard; tin point; triple point of water; zinc point; comparator; International Practical Temperature Scale of 1968; IPTS-68; oxygen point; platinum resistance thermometer; *J. Res.* **80A** No. 3, 477-504 (1976).

Temperature wave; thermal diffusivity; thermal relaxation; anharmonic crystal; computer simulation; energy transport; heat pulse; interatomic potential; molecular dynamics; second sound; shock wave; stress wave; *16138.*

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Tensile stress; cadmium telluride; elastic compliance tensor; elastic moduli; extrinsic damage thresholds; high-power lasers; infrared materials; *SP462,* pp. 119-125 (Dec. 1976).

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Tensor products; convolution; Hilbert space; separation of variables; spectral measure; *J. Res.* **80B** No. 3, 347-351 (1976).

Tentative standards; building codes; industrialization; less-developed country; SASO; Saudi Arabia; standardization; *NBSIR 75-976.*

Tents; tests; uniforms; upholstered furniture; apparel; burn injury; carpets; draperies; fabrics; flammability; heat flux; standards; *16144*.
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Testing facilities; building technology; information handling; measurement services; Philippines; standardization; *NBSIR 76-1083*.
Testing machine; creep; instrumentation; stress rupture; *NBSIR 76-1074*.
Tests; dynamic tests; earthquake simulator; shake table; structural engineering; *SP444*, pp. V-25—V-34 (Apr. 1976).
Tests; fabric flammability; fabrics; ignition; heat energy; *NBS-GCR-76-70*.

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Thin film; ZnSe; 10.6 μm; absorbing inclusions; damage statistics; laser damage; reflectors; ThF_4; *SP435*, pp. 216-229 (Apr. 1976).

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Thin-film coating; alkali halides; antireflectance coating; chalcogenide glasses; infrared optical properties; laser damage; optical absorption; optical scattering; *SP462*, pp. 214-220 (Dec. 1976).

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Threshold; atom; collision; Coulomb-interaction; electron; energy exchange; ionization; *15884*.

Threshold; damage threshold; etching; flame polishing; fused silica; hydroxyl; ion polishing; polishing; roughness; surface damage; thin films; *SP462*, pp. 310-314 (Dec. 1976).

Threshold photoelectron spectroscopy; coincidence; mass spectrometry; photoionization; propane; propane-d_2; propane-d_6; propane-d_8; *16590*.

Thrown objects tests; dispersion tests; lawn mowers; penetration tests; power lawn mowers; safety standard; *NBSIR 76-1022*.

Thyroid monitoring; bioassay; I-125 uptake; *SP456*, pp. 371-379 (Nov. 1976).

Tides; wind; buildings; cyclones; disasters; structural engineering; *BSS86*.

$TiFeH_x$ alloys; volume effects; charge flow; isomer; Mössbauer; phase diagram; *16597*.

Time; broadcast; communication; frequency; ratio; synchronization; *16496*.

Time; time code; clock; microprocessor; satellite; *TN681*.

Time and frequency; acoustic quantities; electrical quantities; electromagnetic quantities; end-use measurements; ionizing radiation; measurement activities; measurement institutions; mechanical quantities; National Measurement System; optical quantities; *NBSIR 75-943*.

Time and frequency; acoustics; atomic properties; economics; electrical quantities; ionizing radiation; mechanical quantities; national measurement system; optical quantities; surface properties; thermal quantities; *NBSIR 75-947*.

Time and frequency; clocks; frequency and time; measurement of time and frequency; *16569*.

Time and frequency; time scales; users of NBS radio broadcasts; atomic frequency standards; aviation industry; electric power industry; National Measurement System, position location; shipping and boating industries; Standards laboratories; *SP445-1*.

Time calibration; time signals; broadcast of standard frequencies; frequency calibration; high frequency; low frequency; standard frequencies; television color subcarrier; *SP432*.

Time code; clock; microprocessor; satellite; time; *TN681*.

Time comparison; atomic clocks; frequency stability; portable clocks; rubidium frequency standard; *16489*.

Time delay spectrometry; tissue; transmission; velocity; attenuation; phase; swept frequency; *SP453*, pp. 81-95 (Oct. 1976).

Time dependence; frequency dependence; laser damage; spot size dependence; *SP462*, pp. 338-345 (Dec. 1976).

Time difference measurements; time-domain frequency stability; time interval; frequency measurement; frequency mixing; global positioning system; isolation amplifiers; low-noise amplifiers; precision frequency measurements; precision time measurements; *NBSIR 75-827*.

Time domain; transient; automated measurement; pulse; rise time; sampling oscilloscope; spectrum amplitude; *16477*.

Time domain measurements; time domain reflectometry; homomorphic deconvolution; *16518*.

Time domain reflectometry; homomorphic deconvolution; time domain measurements; *16518*.

Time interval; frequency measurement; frequency mixing; global positioning system; isolation amplifiers; low-noise amplifiers; precision frequency measurements; precision time

measurements; time difference measurements; time-domain frequency stability; *NBSIR 75-827.*

Time measurement; chronograph; frequency-stability measurement; instrumentation; laboratory technique; *TN691.*

Time of analysis in NAA and AAS; trace element content in liver biopsies; trace element content in tumor bearing animals; Wilson's disease; atomic absorption spectroscopy (AAS); comparison between NAA and AAS; *SP422,* pp. 231-238 (Aug. 1976).

Time resolution; aerosol; California aerosol monitoring program; elemental analysis; ion beam analysis; monitoring; particle sizing; *SP422,* pp. 1119-1136 (Aug. 1976).

Time resolved damage; adhesion effect; laser induced damage; optical probe technique; thin film; *SP435,* pp. 284-288 (Apr. 1976).

Time scale; time standards; clocks; frequency accuracy; frequency stability; frequency standards; infrared frequency multiplication; noise; *16488.*

Time scale simulation; frequency stability; international atomic time; models; simulation; *TN689.*

Time scales; users of NBS radio broadcasts; atomic frequency standards; aviation industry; electric power industry; National Measurement System, position location; shipping and boating industries; Standards laboratories; telephone industry and specialized carriers; *SP445-1.*

Time signals; broadcast of standard frequencies; frequency calibration; high frequency; low frequency; standard frequencies; television color subcarrier; time calibration; *SP432.*

Time standards; application of standards; basic standards; cesium standards; frequency accuracy; frequency stability; frequency standards; hydrogen standards; ion storage; laser stabilization; rubidium standards; saturated absorption; *15736.*

Time standards; clocks; frequency accuracy; frequency stability; frequency standards; infrared frequency multiplication; noise; time scale; *16488.*

Time to ignition; fire performance tests; flame spread; heat input; heat release rate; limiting oxygen index; radiant panel; smoke density; *16136.*

Time-domain deconvolution; deconvolution; impedance profiling; impediography; impulse response; *SP453,* pp. 253-258 (Oct. 1976).

Time-domain frequency stability; time interval; frequency measurement; frequency mixing; global positioning system; isolation amplifiers; low-noise amplifiers; precision frequency measurements; precision time measurements; time difference measurements; *NBSIR 75-827.*

Timetable for metrication; conversion to metric; government metrication; metrication; metric system; SI; *16231.*

Tin; binding energy shifts; core level shifts; *16015.*

Tin oxide electrode; transparent electrode; adsorption; anodic oxidation; electrocatalysis; semiconductor electrode; *SP455,* pp. 175-181 (Nov. 1976).

Tin plate; underplatings for gold; wear of gold; contact lubrication; corrosion inhibitors; electrical contacts; gold plate; palladium; polymer in gold; porosity in gold; solder plate; tin-nickel alloy; *SP452,* pp. 64-71 (Sept. 1976).

Tin point; triple point of water; zinc point; comparator; International Practical Temperature Scale of 1968; IPTS-68; oxygen point; platinum resistance thermometer; temperature standard; *J. Res.* **80A** No. 3, 477-504 (1976).

Tin-nickel alloy; tin plate; underplatings for gold; wear of gold; contact lubrication; corrosion inhibitors; electrical contacts; gold plate; palladium; polymer in gold; porosity in gold; solder plate; *SP452,* pp. 64-71 (Sept. 1976).

Tire noise; transportation noise; truck; acoustics; noise measurement; noise (sound); *15792.*

Tire noise; transportation noise; truck; acoustics; noise measurement; noise (sound); *16370.*

Tire pressure; air; building codes; computer tapes; energy; fire; helmets; mobile homes; phase diagrams; *DIM/NBS* **60,** No. 12, 1-24 (1976).

Tire-pavement interface forces; wet pavement; accident reduction, skidding; correlation, skid resistance; highway safety; measurement, skid resistance; pavement, skid resistance; pavement wetting system; *NBSIR 76-1133.*

Tires; noise; pavement macrotexture; profile tracer; *NBS-GCR-75-35.*

Tishomingo; alloy; austenite; electron microscopy; iron-nickel; martensite; meteorite; *15764.*

Tissue; trace element analysis; water pollution; atomic absorption; bluegills; cadmium; fish; heavy metal; *SP422,* pp. 1063-1072 (Aug. 1976).

Tissue; transmission; velocity; attenuation; phase; swept frequency; time delay spectrometry; *SP453,* pp. 81-95 (Oct. 1976).

Tissue; tumor; ultrasonic; velocity; absorption; attenuation; brain; neoplasm; TAST; thermal effects; *SP453,* pp. 153-163 (Oct. 1976).

Tissue; ultrasound; velocity; acoustic imaging; acoustic microscopy; attenuation; frequency dependence; impedance; microstructural analysis; *SP453,* pp. 261-267 (Oct. 1976).

Tissue characterization; tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; ultrasound; velocity; absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; *SP453.*

Tissue characterization; tissue signature; ultrasonic diagnosis; ultrasound; applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; R & D incentives; *SP453,* pp. 7-10 (Oct. 1976).

Tissue characterization; tissue parameters; tumor detection; ultrasound; diagnosis; Doppler effect; optimization; resonance; scattering; *SP453,* pp. 11-17 (Oct. 1976).

Tissue characterization; ultrasound; blood; cross-section; diagnosis; scattering; standardization; *SP453,* pp. 29-47 (Oct. 1976).

Tissue characterization; ultrasonic spectroscopy; ultrasound diagnosis; acoustic impedance; Bragg diffraction; computer processing; frequency-dependent attenuation; internal scattering; myocardial infarction; scattering; surface scattering; *SP453,* pp. 167-196 (Oct. 1976).

Tissue characterization; ultrasound; Bragg diffraction; diagnosis; frequency dependence; orientation dependence; scattering; *SP453,* pp. 197-206 (Oct. 1976).

Tissue characterization; ultrasound; diffraction; Fourier transform; scattering; *SP453,* pp. 213-228 (Oct. 1976).

Tissue equivalent; calorimeter; dosimetry; fast neutron; *SP456,* pp. 327-333 (Nov. 1976).

Tissue parameters; tumor detection; ultrasound; diagnosis; Doppler effect; optimization; resonance; scattering; tissue characterization; *SP453,* pp. 11-17 (Oct. 1976).

Tissue parameters; ultrasound; velocity; absorption; attenuation; mammalian tissues; *SP453,* pp. 21-28 (Oct. 1976).

Tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; ultrasound; velocity; absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; *SP453.*

Tissue signature; ultrasonic diagnosis; ultrasound; applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; R & D incentives; tissue characterization; *SP453,* pp. 7-10 (Oct. 1976).

Tissue structure; ultrasound; color-coded B-scan; Fourier transform; spectral analysis; *SP453*, pp. 97-107 (Oct. 1976).

Tissues; ultrasound; acoustic attenuation; acoustic velocity; breast tumor; computerized tomography; heart; reconstruction; refractive index; synthetic focus; *SP453*, pp. 109-119 (Oct. 1976).

Titanium; corrosion; microstructures; *15765*.

Titanium; field-ion microscopy; hydrogen; *15773*.

Titanium; transducer calibration; ultrasonic reference blocks; acoustic emission; aluminum; fatigue cracks; flat bottomed holes; standards; steel; *16252*.

Titanium; transmission electron microscopy; microstructures; *15777*.

Titanium; wear; curing agent; fretting; silicone resin; solid lubricants; *SP452*, pp. 124-131 (Sept. 1976).

Titanium alloy; electron beam welding; fatigue; fracture toughness; low temperature tests; mechanical properties; *NBSIR 76-836*.

Titanium alloys; aluminum alloys; composites; elastic properties; engineering materials; fatigue; fracture; iron alloys; cryogenic temperatures; maraging steels; mechanical properties; nickel alloys; phenolformaldehyde; stainless steels; superconducting machinery; *NBSIR 76-848*.

Titanium alloys; crack propagation; cryostats; fracture tests; low temperature tests; mechanical tests; *16640*.

Titanium alloys; fatigue crack propagation; fracture toughness; J-integral; low temperature tests; *16531*.

Titanium dioxide; acetonitrile; cyclic voltammetry; electrochemistry; nonaqueous; semiconductor; silicon; *SP455*, pp. 149-152 (Nov. 1976).

Titanium dioxide; transition-metal oxides; defect states; *d*-electrons; electrolyte electroreflectance; surface states; *SP455*, pp. 125-131 (Nov. 1976).

Titanium ultrasonic standards; ultrasonics; aluminum ultrasonic standards; ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; metallurgical variables; nondestructive evaluation; *NBSIR 76-984*.

TlBr; isoelectronic systems; *16393*.

TLD; dosimetry; ion chamber; patient; precision; therapy; *SP456*, pp. 343-350 (Nov. 1976).

TLD; environmental radiation measurements; error; integrating detectors; *SP456*, pp. 187-198 (Nov. 1976).

TLD reliability; TLD systems; decentralized TLD; dosimeters; *SP456*, pp. 181-185 (Nov. 1976).

TLD systems; decentralized TLD; dosimeters; TLD reliability; *SP456*, pp. 181-185 (Nov. 1976).

TlN_3 structure; ionic crystal; KN_3 structure; low temperature study; monovalent metal azides; NaN_3 structure; neutron diffraction; RbN_3 structure; thermal motion; *15973*.

Toeplitz matrix; Hankel matrix; *J. Res.* **80B** No. 2, 269-272 (1976).

Tokamak plasmas; atomic oscillator strengths; beam-foil spectroscopy; fusion plasma research; plasma radiative losses; sodium isoelectronic sequence; *16320*.

Tolerance limits; noncentral *t*-distribution; normal distribution; statistics; *J. Res.* **80B** No. 3, 343-346 (1976).

Tool, market; aggregation, market; market aggregation; *NBS-GCR-ETIP-73-01*.

Topographical model; wind load; wind profile; wind tunnel; bridge; gust; meteorological data; *SP444*, pp. II-1—II-20 (Apr. 1976).

Topography; x ray; asymmetric; diffraction; intensifier; *16356*.

Topside; absorption; high latitude; ionosphere; ionospheric scattering; irregularity; satellite; scintillation; spread-F; *16641*.

Tornado; wind loads; building code; damage classification; extreme wind; *SP444*, pp. I-34—I-39 (Apr. 1976).

Tornadoes; wind; missiles; nuclear engineering; structural engineering; *NBSIR 76-1050*.

Tornadoes, wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; *SP444*, pp. V-35—V-49 (Apr. 1976).

Tornados; wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; *NBS-GCR-75-36*.

Tornados; wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; *NBS-GCR-75-37*.

Tornados; wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; *NBS-GCR-75-38*.

Torque; magnet; magnetization; *16546*.

Torsional excitation; damping; damping coefficients; shear modulus; soil; tests; *SP444*, pp. III-72—III-83 (Apr. 1976).

Torsional frequencies; 2-butanone (methyl ethyl ketone); enthalpy; entropy; equilibrium constant of formation; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; internal rotational barrier height; *JPCRD* **5**, No. 2, 319-328 (1976).

Torsional oscillation; λ-point; barrier to rotation; crystal; crystal structure; hexamethylbenzene; hindered rotation; phase transition; *16137*.

Total internal reflection; emission anisotropy; fluorescence; photodetectors; polarization; quantum counters; rhodamine B chloride; spectrofluorimetry; *16430*.

Total mercury; water; Chesapeake Bay; elemental sulfur; flameless atomic absorption; petroleum; plankton; sediments; *15874*.

Toxic metals; trace determination; aquatic insects; atomic absorption; clean room; fish; mini-computer; sample preparation; *SP422*, pp. 627-632 (Aug. 1976).

Toxicity; bibliographies; building fires; construction materials; fire departments; fire detection system; fire tests; flame detectors; flammability tests; hazard analysis; interior furnishings; *NBSIR 76-1120*.

Toxicity; bioassay; combustion products; fire; hazard assessment; *16204*.

Toxicity; upholstery; bedding; beds; carbon dioxide; carbon monoxide; combustion products; fire gases; fire hazards; furniture; life hazard; oxygen; smoke; temperature; *NBS-GCR-73-1*.

Toy safety; x-ray units; computer power; computer standard; corrosion; environment; health care; housing production; I-R 100 awards; NIKE missile; papers available; stereology; *DIM/NBS* **60**, No. 11, 1-24 (1976).

T(p,n)^{3}He reaction; associated particle technique; neutron detector; neturon flux monitor; neutron standards; neutrons; *16159*.

Trace determination; aquatic insects; atomic absorption; clean room; fish; mini-computer; sample preparation; toxic metals; *SP422*, pp. 627-632 (Aug. 1976).

Trace analyses; cadmium; environmental Standard Reference Materials; isotope dilution; lead; molybdenum; rubidium; strontium; *16221*.

Trace analysis; accuracy; activation analysis; analytical chemistry; charged particle activation analysis; cross sections; excitation functions; fast neutron activation analysis; fast particle activation analysis; interferences; *SP422*, pp. 1189-1214 (Aug. 1976).

Trace analysis; accuracy; analysis; analytical chemistry; sample handling; sampling; *SP422. Volume I and II.*

Trace analysis; analytical error; geochemical variance; particle size distribution; particle size errors; sampling errors; *SP422*, pp. 421-427 (Aug. 1976).

Trace analysis; background correction; differential pulse polarography; dropping mercury electrode; electroanalysis; pulse polarography; *SP422*, pp. 871-879 (Aug. 1976).

Trace analysis; baseline studies; gas chromatography; gas chromatography-mass spectrometry; hydrocarbons; liquid chromatography; petroleum analysis; *TN889*.

Trace analysis; carcinogens; food; nitrosamines; *SP422*, pp. 727-736 (Aug. 1976).

Trace analysis; trace metals; atomic absorption spectroscopy; fish analysis; sample size variations; *SP422*, pp. 163-172 (Aug. 1976).

Trace analysis; triclosan; 2-hydroxy-2′,4′,4-trichlorodiphenyl ether; bacteriostats; blood analysis; gas chromatography; *SP422*, pp. 851-859 (Aug. 1976).

Trace analysis; water sampling; contamination; geological sample; rocks and minerals; sample preparation; sampling; *SP422*, pp. 285-297 (Aug. 1976).

Trace analysis; x-ray fluorescence; mineral analysis; *SP422*, pp. 1109-1118 (Aug. 1976).

Trace analysis of lead; waters, lead in; accuracy of atomic absorption analytical techniques; accuracy of isotope dilution analytical techniques; errors in lead analyses; lead; lead contamination evaluation and control; *SP422*, pp. 321-351 (Aug. 1976).

Trace detection; tunable lasers; discharge; discharge tubes; hollow cathode; spectroscopy; *16604*.

Trace element analysis; x-ray fluorescence; accuracy; activation analysis; airborne particulates; air filter analysis; atomic absorption; emission spectroscopy; environmental pollutants; intercomparisons; multi-element analysis; *SP422*, pp. 173-188 (Aug. 1976).

Trace element analyses; accuracy; blood lead analyses; clinical chemistry; industrial lead hygiene; interlaboratory correlations; lead hygiene control; occupational exposure standard criteria; occupational health control; precision; *SP422*, pp. 275-282 (Aug. 1976).

Trace element analyses; atomic absorption spectrometry; blood analyses; contaminations; flameless methods; lead; lead blood analyses; methodology; *SP422*, pp. 715-719 (Aug. 1976).

Trace element analysis; accuracy; activation analysis; air filter analysis; analytical quality control; atomic absorption spectrometry; environmental analysis; fresh water analysis; intercomparisons; precision; round-robin experiments; *SP422*, pp. 189-197 (Aug. 1976).

Trace element analysis; accuracy and precision; comparison of trace analytical methods; contamination; rocks and ores; sample preparation; *SP422*, pp. 773-790 (Aug. 1976).

Trace element analysis; errors of analysis; homogenization; neutron activation analysis; sample preparation; standard materials; *SP422*, pp. 1293-1304 (Aug. 1976).

Trace element analysis; water pollution; atomic absorption; bluegills; cadmium; fish; heavy metal; tissue; *SP422*, pp. 1063-1072 (Aug. 1976).

Trace element analysis; wet ashing; ashing techniques; dissolution; dry ashing; organic materials analysis; *SP422*, pp. 491-507 (Aug. 1976).

Trace element concentrations; neutron activation analysis; particulates; sampling; species; *15783*.

Trace element content in liver biopsies; trace element content in tumor bearing animals; Wilson's disease; atomic absorption spectroscopy (AAS); comparison between NAA and AAS; neutron activation analysis (NAA); *SP422*, pp. 231-238 (Aug. 1976).

Trace element content in tumor bearing animals; Wilson's disease; atomic absorption spectroscopy (AAS); comparison between NAA and AAS; neutron activation analysis (NAA); time of analysis in NAA and AAS; *SP422*, pp. 231-238 (Aug. 1976).

Trace element models; volcanic rocks; analytical techniques; fractional crystallization; geochemistry; isotope dilution; partial melting; rare earth elements; *SP422*, pp. 937-949 (Aug. 1976).

Trace element water analysis; water filtration; water sampling apparatus; anodic stripping voltammetry; flameless atomic absorption; interstitial water; Lake Superior chemical analysis; *SP422*, pp. 1073-1088 (Aug. 1976).

Trace elements; accuracy; Atomic Absorption Spectrometry; Caribbean; precision; Puerto Rico; replicates; sediments; standard; *SP422*, pp. 1089-1102 (Aug. 1976).

Trace elements; accuracy; biological materials; data interpretation; standard materials; *SP422*, pp. 65-77 (Aug. 1976).

Trace elements; accuracy and precision; clinical chemistry; quality control; surrogate specimens; *SP422*, pp. 35-40 (Aug. 1976).

Trace elements; activation analysis; adsorption isotherm; environmental samples; mercury; preconcentration; *SP422*, pp. 669-699 (Aug. 1976).

Trace elements; air particulates; blood; chemistry; computer graphics; geochemistry; medicine; pattern recognition; *SP422*, pp. 151-162 (Aug. 1976).

Trace elements; air sampling; atomic absorption spectrophotometry; high temperature ashing; *SP422*, pp. 1053-1061 (Aug. 1976).

Trace elements; analytical methods; coal; environmental samples; environmental standards; fly ash; instrumental neutron activation analysis (INAA); instrumental photon activation analysis (IPAA); natural radioactivity; *SP422*, pp. 211-223 (Aug. 1976).

Trace elements; biological material; biological standards; data evaluation; distillation; food composition; gamma spectrometry; inorganic separators; isotopic exchange; multielement determination; neutron activation; radiochemical separation; *SP422*, pp. 1173-1180 (Aug. 1976).

Trace elements; chemical analysis; environmental samples; long-term storage; microbiologicals; organics; pesticides; radionuclides; sample handling; sampling; *TN929*.

Trace elements; high-temperature alloys; intergranular segregation; macro-segregation; sampling problems; *SP422*, pp. 1017-1022 (Aug. 1976).

Trace elements; isotope dilution; NBS Standard Reference Material; preconcentration; spark source mass spectrometry; steel; *15889*.

Trace elements; trace elements in water; water; filtering water; river water; sampling water for trace elements; suspended particulates in water; Teflon water sampler; *SP422*, pp. 439-455 (Aug. 1976).

Trace elements; water; wet chemical analysis; atomic absorption analysis; Californium-252; Mahoning River; neutron activation analysis; pollution; sediment; *SP422*, pp. 225-230 (Aug. 1976).

Trace elements; zinc; atomic absorption spectrophotometry; calcium; container effects; copper; magnesium; potassium; serum minerals; serum storage effects; sodium; temperature effects; *SP422*, pp. 575-591 (Aug. 1976).

Trace elements in polyethylene powder; gamma counting efficiency; germanium detectors; instrumental neutron activation analysis; particulate sample geometry; *SP422*, pp. 1275-1281 (Aug. 1976).

Trace elements in water; water; filtering water; river water; sampling water for trace elements; suspended particulates in water; Teflon water sampler; trace elements; *SP422*, pp. 439-455 (Aug. 1976).

Trace metal; analysis; ashing; blood lead; contamination; dairy products; digestion; interferences; losses; mercury; *SP422*, pp. 661-668 (Aug. 1976).

Trace metal analysis; accuracy; flameless atomic absorption; freshwater; interlaboratory comparison; method evaluation; *SP422*, pp. 247-265 (Aug. 1976).

Trace metals; atomic absorption spectroscopy; fish analysis; sample size variations; trace analysis; *SP422*, pp. 163-172 (Aug. 1976).

Traceability; assurance; measurement; radioactivity; radiopharmaceutical; standards; *SP456*, pp. 71-76 (Nov. 1976).

Traceability; calibration; measurement; nondestructive assay; nuclear; safeguards; *16414*..

Traceability; diagnosis; measurement accuracy; medical facilities; regulatory; therapy; *SP456*, pp. 139-146 (Nov. 1976).

Traceability; uncertainty; measurement; *15975*.

Track-etch; films; images; neutron radiography; nondestructive tests; real-time imaging; thermoluminescence; *15796*.

Traffic noise; airborne and structure-borne sounds; aircraft noise intrusion; annoyance; appliance noise; health and hearing hazards; household noise; legal and community action; loudness; noise control and abatement; *H119*.

Traffic noise; alarm signals; hearing; loudness functions; masking; sirens; speech recognition; *16573*.

Training; Treaty of the Meter; education; International System of Units; metrication; metric education; metric system; *SP441*.

Trajectories; classical scattering matrix theory; collision theory; scattering theory; *16593*.

Trajectories; transition-state theory; chemical reactions; chlorine molecules; classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; *16627*.

Trajectories; uniform approximation; chemical reactions; classical scattering matrix theory; collision theory; hydrogen atoms; hydrogen molecules; scattering theory; *16054*.

Trajectories; vibrational energy; chemical reactions; classical probability matrix theory; classical scattering matrix theory; collision theory; energy transfer in collisions; hydrogen molecules; information theory; scattering theory; *16607*.

Trajectory control; computer control of automation systems; computer interface; computer software for robot control; hierarchical control of manipulators; position servos; *NBSIR 75-973*.

Transceiver; battery performance standard; law enforcement communications, Law Enforcement Standards Laboratory; personal/portable transceivers; primary battery; secondary battery; *16296*.

Transducer; bias pressure; calibration; dynamic calibration; dynamic pressure; high pressure; liquid medium; pogo pressure; pressure source; pressure transducer; sinusoidal; space shuttle; *TN927*.

Transducer; calibration; dynamic; dynamic calibration; dynamic pressure; dynamic pressure source; liquid column; pressure; pressure source; pressure transducer; sinusoidal pressure; *TN914*.

Transducer; coatings; photoflash bulb; pressure transducer; protective coatings; thermal radiant-energy response; thermal transient response; *NBSIR 76-1060*.

Transducer; electroacoustic; integration; *15804*.

Transducer; ultrasonics; electromagnetic transducer; EMAT; *16616*.

Transducer; zero shift; calibration; dynamic; electronic flash; photographic flashbulb; pressure; pressure measurement; pressure transducer; thermal transient; *TN905*.

Transducer; zero shift; calibration; dynamic; electronic flash; photoflash bulb; pressure; pressure measurement; pressure transducer; pressure transducer response; response; thermal transient; *NBSIR 76-1038*.

Transducer calibration; ultrasonic reference blocks; acoustic emission; aluminum; fatigue cracks; flat bottomed holes; standards; steel; titanium; *16252*.

Transducers; piezoelectric; polymeric transducer; polymers; polyvinyl fluoride; polyvinylidene fluoride; stress gages; *16141*.

Transducers; triplet formation; absolute quantum efficiency; absolute quantum yield; calorimetry; luminescence; photoacoustic spectrometer; piezocalorimeter; *J. Res.* **80A** No. 3, 413-419 (1976).

Transducers; zero shift; coatings; dynamic; dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; *NBSIR 76-1144*.

Transfer; benefits, industry-society; materials research; measurements-standards; NBS-industry; *16280*.

Transfer Hamiltonian; field emission; surface density of states; *16418*.

Transfer standards; ultraviolet absorbance standards; absorbance linearity; accuracy; acidic potassium dichromate solutions; calibration of ultraviolet spectrophotometers; liquid filters; *J. Res.* **80A** No. 4, 631-636 (1976).

Transform analysis; automobile; economic; energy; model; *SP403*, pp. 65-74 (June 1976).

Transformations; weighting; interlaboratory comparisons; invariance; models; precision; precision of measurement; repeatability; reproducibility; test methods; *15909*.

Transformer; transformer overcurrent protection; high voltage transformer protection; overcurrent; overcurrent protection; solid-state overcurrent protection circuit; *16381*.

Transformer overcurrent protection; high voltage transformer protection; overcurrent; overcurrent protection; solid-state overcurrent protection circuit; transformer; *16381*.

Transformer steel; backscattered electrons; domain walls; magnetic domains; scanning electron microscope; silicon steel; *15921*.

Transformers; askarel; capacitors; insulating fluids; liquid insulators; polychlorinated biphenyls; *NBSIR 76-1054*.

Transforms; execution; execution monitoring; FORTRAN analysis; source code instrumenting; static analysis; *15918*.

Transient; automated measurement; pulse; rise time; sampling oscilloscope; spectrum amplitude; time domain; *16477*.

Transient heat flows; building heat transfer; computer programs; dynamic thermal performance; heat flow analysis; heating and cooling loads; thermal analysis; *15762*.

Transient techniques; heat capacity; high pressures; thermal conductivity; thermal diffusivity; thermal properties; *15709*.

Transient thermal gradients; ultrasonics; velocity; absorption; attenuation; impedance gradient; *SP453*, pp. 143-151 (Oct. 1976).

Transistor, power; current crowding; hot spots; reliability; safe operating area limits; second breakdown; semiconductor devices; thermal resistance; *16328*.

Transistors; failure analysis; hot spots; integrated circuits; laser scanner; measurement method; nondestructive test; nonlinear operation; optical scanner; reliability; *SP400-27*.

Transistors; ultrasonic bonding; wire bonds; x-ray photoelectron spectroscopy; acoustic emission; beam-lead bonds; bias-temperature stress test; boron redistribution; capacitance-voltage methods; charge-coupled device structures; Darlington pairs; deep depletion; *SP400-19*.

Transition; turbulent flow; buoyancy; channels; film boiling; forced convection; helium I; helium II; mixed convection; nucleate boiling; subcritical; supercritical; *TN675*.

Transition elements; triphenylphosphine; tungsten bronze; electrocatalysis; fuel cells; mixed oxides; oxygen reduction; phosphoric acid; ternary metal-sulfur arrays; *NBSIR 75-742*.

Transition metal; zero phonon line; charge transfer, color cen-

ters; crystal field; d^4 ions; EPR; iron 4+; optical absorption; perovskite; strontium titanate; *16201*.

Transition metal carbide; adsorption; catalysis; electronic structure; surface states; *SP455*, pp. 87-92 (Nov. 1976).

Transition metal carbides; transition metal oxides; tungsten bronze; tungsten carbide; electrocatalysis; heteropolyanions; phosphotungstate complex ions; "spillover" effect; *SP455*, pp. 167-174 (Nov. 1976).

Transition metal complexes; catalysis; chemisorption theory; metal clusters; molecular orbitals; quantum chemistry; *SP455*, pp. 67-86 (Nov. 1976).

Transition metal ions; chromium 3+; crystal vacancies; cubic crystals; depolarization; impurity compensation; luminescence; magnesium oxide; MgO; optical properties; polarized luminescence; symmetry; *16521*.

Transition metal oxides; catalysis; chemisorption; cluster states; electronic structure; energy bands; perovskites; surface states; *SP455*, pp. 21-52 (Nov. 1976).

Transition metal oxides; tungsten bronze; tungsten carbide; electrocatalysis; heteropolyanions; phosphotungstate complex ions; "spillover" effect; transition metal carbides; *SP455*, pp. 167-174 (Nov. 1976).

Transition metals; Co; Cr; *d*-band widths; electronic structure; Fe; ferromagnetism; soft x-ray emission; soft x-ray spectra; *15780*.

Transition moment; ab initio calculation; O_2 absorption; oscillator strength; *15872*.

Transition probabilities; energy loss; O_2; oscillator strengths; oxygen; *15999*.

Transition probabilities; wave functions; ions; oscillator strengths; quantum mechanics; spectroscopy; *16209*.

Transition probabilities for U I; uranium spectrum; lifetimes in U I; oscillator strengths for U I; *J. Res.* **80A** No. 1, 1-7 (1976).

Transition probabilities for U II; uranium spectrum; oscillator strengths for U II; *J. Res.* **80A** No. 3, 429-438 (1976).

Transition probability; CO^+; CO_2^+; coincidence; electron impact; ions; lifetime; molecule; N_2^+; radiative; *15912*.

Transition probability; comet; electric-dipole transition; excited states; NH; spin-orbit coupling; *16502*.

Transition probability; U I; uranium; atomic beam; delayed coincidence; imprisonment; lifetime; mean life; resonance radiation; *16322*.

Transition radiation; electron optics; *15760*.

Transition region-sun; ultraviolet spectrum-sun; chromosphere-sun; coronal holes; diffusion; *15717*.

Transition temperature; triple point; ethane; heat capacity; heat of fusion; heat of transition; *16522*.

Transition-metal oxides; adsorption; electron spectroscopy; ligand-field splitting; surface excitons; surface states; *SP455*, pp. 133-138 (Nov. 1976).

Transition-metal oxides; defect states; *d*-electrons; electrolyte electroreflectance; surface states; titanium dioxide; *SP455*, pp. 125-131 (Nov. 1976).

Transition-state theory; chemical reactions; collision theory; hydrogen atoms; hydrogen molecules; indistinguishable particles; nuclear spin; rate coefficients; *16214*.

Transition-state theory; chemical reactions; chlorine molecules; classical scattering matrix theory; collision theory; cross sections; hydrogen atoms; rate coefficients; scattering theory; trajectories; *16627*.

Translation vectors; cerous magnesium nitrate; crystal structure; *g*-factors; ground state energy; Luttinger-Tisza method; *16512*.

Translational diffusion coefficient; Zimm theory; bead-spring model; block copolymers; dilute polymer solutions; limiting viscosity number; Mandelkern-Flory-Scheraga equation; molecular weight determination; sedimentation coefficient; *16026*.

Translucency; transmittance; Vitrolite glass; blurring effect; edge loss; error analysis; flux loss; plastics; reflectance; scattering; spectrophotometry; *TN594-12*.

Transmission; cable assembly; coaxial cable; insertion loss; mobile antenna; mobile transceiver; *16294*.

Transmission; ultrasound; velocity; attenuation; breast tissue; broadband; high resolution; imaging; large aperture; pathology; pellicle; phase-contrast; *SP453*, pp. 121-133 (Oct. 1976).

Transmission; velocity; attenuation; phase; swept frequency; time delay spectrometry; tissue; *SP453*, pp. 81-95 (Oct. 1976).

Transmission electron microscopy; microstructures; titanium; *15777*.

Transmission electron microscopy; twinning; aluminum oxide; microhardness; plastic deformation; slip; *15825*.

Transmission electron microscopy; δ'; Ll_2; metastable phase; ordering reaction; satellites; spinodal decomposition; superlattice reflections; *15840*.

Transmission electron microscopy; vapor deposition; cadmium telluride; growth kinetics; mechanical properties; microstructure; stoichiometry; *SP462*, pp. 100-118 (Dec. 1976).

Transmission loss; airborne sound transmission; architectural acoustics; building acoustics; sound reduction index; sound transmission loss; *15708*.

Transmission topography; x-ray diffraction topography; crystal perfection; Czochralski growth; domain walls; magnetic domains; nickel single crystals; surface reflection topography; *16503*.

Transmittance; bibliography; emittance; heat transfer; measurement techniques; periodic surfaces; polarization; random surfaces; reflectance; reflectance of coherent radiation; scattering; scattering theory; surface roughness; *J. Res.* **80A** No. 2, 207-220 (1976).

Transmittance; Vitrolite glass; blurring effect; edge loss; error analysis; flux loss; plastics; reflectance; scattering; spectrophotometry; translucency; *TN594-12*.

Transmittance characteristics; ultraviolet-visible filters; evaporated metal-on-quartz; filters, transmittance; neutral filters; standard reference materials; *J. Res.* **80A** No. 4, 637-641 (1976).

Transmitted pulse; waveform distortion; ZnSe; KCl; NaCl; pulsed CO_2 TEA laser damage; *SP435*, pp. 107-117 (Apr. 1976).

Transmitted pulse cutoff; variable pulse duration; alkali halides; bulk damage; longitudinal mode control; pulsed 10.6 μm laser damage; RAP materials; *SP435*, pp. 118-125 (Apr. 1976).

Transmitter; audiofrequency modulation; communications; electromagnetic compatibility; law enforcement; personal transmitter; portable transmitter; radio frequency carrier; *16285*.

Transmitter; base station transmitter; communications; fixed transmitter; FM transmitter; law enforcement; *16286*.

Transmitter; wiretapping; body worn antenna; bugging; eavesdropping; electronic surveillance; microphones; receiver; tape recorder; telephone; *16237*.

Transparent electrode; adsorption; anodic oxidation; electrocatalysis; semiconductor electrode; tin oxide electrode; *SP455*, pp. 175-181 (Nov. 1976).

Transparent electrophotographic material; add-on films; information storage; microforms; *NBSIR 76-991*.

Transparent materials; absorption coefficients; cylindrical configurations; gas pressure; heat transfer; photoacoustic; *15936*.

Transparent materials; barothermal; gas pressure; heat diffusion; heat transfer; optical absorption coefficients; *15916*.

Transparent materials; bulk absorption coefficients; Fourier amplitudes; gas pressure; heat transfer; phase shifts; photoacoustic; surface absorption coefficients; *16558*.

Transpiration; vapor density; glass; incongruent vaporization; *16524*.

Transport coefficients; Zwanzig-Mori formalism; hydrodynamic regime; ideal gas memory function; limit of stability; metastable fluid states; nonhydrodynamic regime; relaxation time; *16601.*

Transport properties; correlation; equation of state; excess function; hydrogen; interpolation methods; least squares; methane; thermodynamic properties; *15731.*

Transport properties; vaporization; viscosity; diffusion; electrical conductivity; magnetohydrodynamics (MHD); phase equilibria; *16321.*

Transport standard; watthour meter; electric energy; electricity; electric power; measurement assurance; *TN930.*

Transport theory; magnetophonon effect; semiconductors; *16643.*

Transportation; urethane; flame spread; flammability; full-scale fire tests; laboratory fire tests; Metrorail cars; neoprene; smoke; *NBSIR 75-971.*

Transportation noise; truck; acoustics; noise measurement; noise (sound); tire noise; *15792.*

Transportation noise; truck; acoustics; noise measurement; noise (sound); tire noise; *16370.*

Transportation noise; truck; acoustics; environmental conditions; noise measurement; noise (sound); *NBSIR 76-1138.*

Transportation problem; average distance; distance; multiple integrals; *16088.*

Transportation safety; effects of mechanical failure on environment; failure prevention; government action; mechanical failure; safety standards; *SP423,* pp. 153-163 (Apr. 1976).

Transverse excitation laser; 2-methyl propene; carbon isotopes; carbonyl fluoride; CO_2 laser photolysis; difluorocarbene; difluorodichloromethane; isotope ratio; nitric oxide; oxygen; tetrafluoroethylene; *16657.*

Trans-1,3-butadiene; electronic structure; multiphoton ionization; *15981.*

Traps; zinc oxide; dislocation; electrochemical; exchange current; semiconductor; *SP455,* pp. 139-148 (Nov. 1976).

Treatments; cotton; fabrics; flame retardants; flammability; phosphorus; polyester; rayon; *NBS-GCR-73-16.*

Treaty of the Meter; education; International System of Units; metrication; metric education; metric system; training; *SP441.*

Tree; block Gaussian elimination; graph; inversion; partitioning; sparse matrix; *J. Res.* **80B** No. 2, 245-257 (1976).

Tree; 2-connected; block-cutpoint tree; graph; *16154.*

Trial proceedings; videotape recording; closed circuit television; court proceedings; court security; *16185.*

Trial proceedings; videotape recording; closed circuit television; court proceedings; court security; *16186.*

Triangular lattice; conditional probability; Ising spin; Monte Carlo method; spin system; *15865.*

Triazine; x ray; diffractometer; direct methods; explosives; single-crystal; *15735.*

Tribology; wear; economic savings of failure prevention; friction; lubrication; mechanical failure; *SP423,* pp. 117-139 (Apr. 1976).

Trichlorosilane; boron measurements; mass spectrometry; semiconductor grade silicon; *SP422,* pp. 709-714 (Aug. 1976).

Triclosan; 2-hydroxy-2′,4′,4-trichlorodiphenyl ether; bacteriostats; blood analysis; gas chromatography; trace analysis; *SP422,* pp. 851-859 (Aug. 1976).

Triglycerides; correlation; esters; heat capacity; oligomers; sebacates; *16275.*

Trimethylarsine; trimethylstibine; antimony; antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; *16628.*

Trimethylene sulfone; 3-methyl sulfolane; pyrolysis; SO_2; *15952.*

Trimethylstibine; antimony; antimony oxide; arsenic; arsenic acid; biomethylation; cacodylic acid; diffusion; flame retardant; oxidation rate; stibinic acid; trimethylarsine; *16628.*

Trinitrotoluene; vapors; calibration device; dinitrotoluene; ethylene glycol dinitrate; explosives; generator; *16402.*

Triphenylphosphine; tungsten bronze; electrocatalysis; fuel cells; mixed oxides; oxygen reduction; phosphoric acid; ternary metal-sulfur arrays; transition elements; *NBSIR 75-742.*

Triple point; ethane; heat capacity; heat of fusion; heat of transition; transition temperature; *16522.*

Triple point of water; vapor pressure; mercury manometer; *15732.*

Triple point of water; vapor pressure of water; precision mercury manometer; *16096.*

Triple point of water; vapor pressure of water; precision mercury manometer; *J. Res.* **80A** No. 3, 505-521 (1976).

Triple point of water; zinc point; comparator; International Practical Temperature Scale of 1968; IPTS-68; oxygen point; platinum resistance thermometer; temperature standard; tin point; *J. Res.* **80A** No. 3, 477-504 (1976).

Triplet formation; absolute quantum efficiency; absolute quantum yield; calorimetry; luminescence; photoacoustic spectrometer; piezocalorimeter; transducers; *J. Res.* **80A** No. 3, 413-419 (1976).

Triplet states; electron energy loss; forbidden transitions; ozone; *15750.*

Tropospheric mixing; Ar-37; atmospheric radioactivity; cosmic-ray reactions; exponential distribution; low-level counting; noble gas separation; on-line computer; pulse shape discrimination; *15744.*

Truck; acoustics; environmental conditions; noise measurement; noise (sound); transportation noise; *NBSIR 76-1138.*

Truck; acoustics; noise measurement; noise (sound); tire noise; transportation noise; *15792.*

Truck; acoustics; noise measurement; noise (sound); tire noise; transportation noise; *16370.*

TTF-TCNQ; eddy currents; electron paramagnetic resonance; microwave conductivity; tetrathiofulvalinium-tetracyanoquinodimethane; *15917.*

TTF-TCNQ; electrical conductivity; organic conductors; tetrathiafulvalenium-tetracyanoquinodimethanide; *16061.*

TTF—TCNQ; d.c. conductivity; microwave conductivity; organic conductors; thermal expansion; *16050.*

TTL; vendor qualification; circuit procurement; component screening; custom circuits; LSI; microelectronics; parameter control; process uniformity; random faults; reliability; test patterns; *16620.*

Tumor; ultrasonic; velocity; absorption; attenuation; brain; neoplasm; TAST; thermal effects; tissue; *SP453,* pp. 153-163 (Oct. 1976).

Tumor; ultrasonic spectroscopy; ultrasound; velocity; absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; *SP453.*

Tumor detection; ultrasound; diagnosis; Doppler effect; optimization; resonance; scattering; tissue characterization; tissue parameters; *SP453,* pp. 11-17 (Oct. 1976).

Tumor dose; quality control; medical physicist; radiation measurement; radiation therapy; *SP456,* pp. 111-118 (Nov. 1976).

Tunable IR laser; air quality measurements; improved resolution spectroscopy; infrared frequency measurements; infrared spectrometer; spin flip laser; *TN670.*

Tunable lasers; discharge; discharge tubes; hollow cathode; spectroscopy; trace detection; *16604.*

Tungsten; carbon monoxide; chemisorption; electron stimulated desorption; ion angular distribution; oxygen; *16398.*

Tungsten; electron polarization; electron scattering; low energy; nickel; single crystals; *15747.*

Tungsten; field ion energy distribution; field ionization; surface density of states; *15752*.

Tungsten; ultraviolet photoelectron spectroscopy; virgin CO; adsorption; carbon monoxide; chemisorption; desorption; photoelectron spectroscopy; photoemission; single crystal; *15851*.

Tungsten; ultraviolet photoemission; adsorption; chemisorption; CO; cyclotron resonance; electron cyclotron resonance; magnetic field; microwave discharge; photoemission; *16016*.

Tungsten; ultraviolet photoemission; valence band; virgin states; α states; β states; adsorption; carbon; carbon monoxide; chemical bonding; chemisorption; density dependent transitions; desorption; dissociative adsorption; electronic states; hydrogen; monolayers; *16419*.

Tungsten; wavelengths; ytterbium; bismuth; gold; hafnium; ionization energies; iridium; lead; lutetium; mercury; osmium; platinum; rhenium; tantalum; thallium; *16420*.

Tungsten; work function; adsorption; nitrogen; physical adsorption; *16460*.

Tungsten; xenon; XPS; carbon monoxide; chemisorption; ESCA; extra-atomic relaxation; formaldehyde; oxygen; photoelectron spectroscopy; physisorption; *16023*.

Tungsten; x-ray crystallography; clusters; metal-metal bonding; metal sulfides; sulfides; *16071*.

Tungsten; x-ray photoelectron spectroscopy; carbon dioxide; carbon monoxide; chemisorption; formaldehyde; oxygen; physisorption; surface chemistry; *16085*.

Tungsten bronze; electrocatalysis; fuel cells; mixed oxides; oxygen reduction; phosphoric acid; ternary metal-sulfur arrays; transition elements; triphenylphosphine; *NBSIR 75-742*.

Tungsten bronze; tungsten carbide; electrocatalysis; heteropolyanions; phosphotungstate complex ions; "spillover" effect; transition metal carbides; transition metal oxides; *SP455*, pp. 167-174 (Nov. 1976).

Tungsten bronzes; Auger electron spectroscopy; electrocatalyst; oxygen reduction; sodium depletion; Tafel plots; *SP455*, pp. 297-303 (Nov. 1976).

Tungsten carbide; electrocatalysis; heteropolyanions; phosphotungstate complex ions; "spillover" effect; transition metal carbides; transition metal oxides; tungsten bronze; *SP455*, pp. 167-174 (Nov. 1976).

Tungsten (100); xenon; crystal field; photoemission; physisorption; *15813*.

Tungsten-rhenium alloys; beryllium oxide; refractory metals; sheathed thermocouples; tantalum; temperature measurements; thermal emf drift; *15797*.

Tunnel diode; directional coupler; fast risetime; flat pulse baseline/topline; pulse generator; step waveform; *U.S. Patent 3,967,140*.

Tunneling; electronics devices; high speed devices; Josephson effect; superconducting devices; superconductivity; *16485*.

Turbine handpiece; amalgam; composite materials; dental gold alloys; dental research; panoramic x ray; silicate cement; *16212*.

Turbulent flow; buoyancy; channels; film boiling; forced convection; helium I; helium II; mixed convection; nucleate boiling; subcritical; supercritical; transition; *TN675*.

Turning points; uniform asymptotic approximations; Weber's equation; error bounds; parabolic cylinder functions; *J. Res.* **80B** No. 4, 437-440 (1976).

Turning points; Whittaker functions; asymptotic analysis; Darboux's method; definite integrals; hypergeometric functions; incomplete gamma function; Legendre functions; ordinary differential equations; saddle points; special functions; *15818*.

Turning-point; viscous flow; Weber's equation; boundary-value problem; eigenvalues; parabolic cylinder functions; resonance; rotating disks; singular perturbations; *16459*.

Twin; wedge; crystal; disclination; dislocation; pseudopentagonal; stacking fault; *15767*.

Twin electrode balancing; anodic stripping voltammetry; background current compensation; differential anodic stripping voltammetry; electrochemical analysis; *SP422*, pp. 881-897 (Aug. 1976).

Twinning; aluminum oxide; microhardness; plastic deformation; slip; transmission electron microscopy; *15825*.

Twinning; computer calculations; crystal structure; epitaxy; lattice misfit; pattern recognition; *TN893*.

Two phase flow; compressibility flow; cryogenics; fluid dynamics; pressure drop; superfluid helium; *16642*.

Two-dimensional flow; flow with longitudinal gradient; flow with transverse gradient; optical anemometry; optical birefringence; optical excess tensor; optical mapping of flow; stress excess tensor; *15775*.

Two-photon absorption; damage thresholds; electron avalanche; picosecond pulses; refractory oxides; standing-wave fields; thin films; *SP462*, pp. 292-300 (Dec. 1976).

Two-photon absorption; nonlinear index of refraction; optical distortion; thermal fracture; *SP435*, pp. 395-405 (Apr. 1976).

Two-photon absorption coefficients; multiphoton processes; nonlinear absorption; nonlinear optical properties; semiconductor optical properties; *SP435*, pp. 369-388 (Apr. 1976).

Two-ports; automatic network analyzer; Q cavity; *15867*.

Two-stage transformers; ac bridges; bridges; platinum thermometers; resistance measurements; thermometry; *16404*.

Two-way television; wired city; wired nation; broadband interactive terminals; cable television uses; checkless society; computer/communications networks; computer/communications services; computer/communications standards; interactive cable television: *NBS-GCR-75-44*.

Type; abstract data types; class; cluster; data abstraction; data type; module; programming methods; program modifications; *16246*.

Type fonts; typesetting; vectorized characters; alphabets; COM; computerized typesetting; digital plotting; graphics; Hershey character set; plotting; *SP424*.

Type II diamond windows; diamond absorption coefficient; laser window heating; laser window testing; *SP435*, pp. 175-188 (Apr. 1976).

Types; capability; capability-based addressing; computer security; extended-type objects; operating system structures; protection; reliable software; reliability; security; small protection domains; *TN919*.

Typesetting; vectorized characters; alphabets; COM; computerized typesetting; digital plotting; graphics; Hershey character set; plotting; type fonts; *SP424*.

Typhoon; wind; wind intensities; cloud seeding; frequency distribution; hurricanes; *SP444*, pp. I-21—I-33 (Apr. 1976).

Typhoons; construction; design; developing countries; earthquakes; low-cost housing; natural disasters; Philippines; socioeconomic aspects; *NBS-GCR-73-21*.

Typhoons; wind loads; buildings; codes and standards; housing; hurricanes; low-rise buildings; natural disaster; structural connections; *NBSIR 75-790*.

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U; 5f electron; actinium; excitation energy; *16581*.

U I; uranium; atomic beam; delayed coincidence; imprisonment; lifetime; mean life; resonance radiation; transition probability; *16322*.

UHF transistor measurement; active devices; hot spots; laser scanning; logic flow observation; LSI testing; nondestructive test; nonlinearity measurement; *15781*.

UHF transistor measurements; device nonlinearity measurements; hot spots, transistor; laser scanning; nondestructive tests; semiconductor devices; *16571*.

UK; USA; fire propagation test; fire tests; smoke density chamber; smoke tests; test comparison; *16125*.

Ultimate strength; bending moments; building codes; column (supports); frames; long columns; reinforced concrete; slenderness ratio; strength; structural analysis; structural design; *16412*.

Ultrapurification; analytical blanks; analytical reagents; contamination control; high-purity reagents; membrane filtration; mercury cathode electrolysis; prepurification; purity definition; reagent contamination; *SP422*, pp. 363-375 (Aug. 1976).

Ultrasonic; velocity; absorption; attenuation; brain; neoplasm; TAST; thermal effects; tissue; tumor; *SP453*, pp. 153-163 (Oct. 1976).

Ultrasonic bonding; wire bond; bond angle; bonding; bond pull test; bond-to-bond spacing; large wire; loop height; microelectronics; nondestructive bond pull test; position of hook; pull rate; pull strength; resolution-of-forces; semiconductor devices; *SP400-18*.

Ultrasonic bonding; wire bonds; x-ray photoelectron spectroscopy; acoustic emission; beam-lead bonds; bias-temperature stress test; boron redistribution; capacitance-voltage methods; charge-coupled device structures; Darlington pairs; deep depletion; dopant profiles; *SP400-19*.

Ultrasonic calorimeter; ultrasonic power measurements; calorimeter; *TN686*.

Ultrasonic cleaning; damage thresholds; fused silica; ion polishing; surface damage; surface roughness; surface structure; thin films; *SP435*, pp. 305-320 (Apr. 1976).

Ultrasonic cleaning; laser damage; metal mirrors; subsurface structure; *SP435*, pp. 90-97 (Apr. 1976).

Ultrasonic diagnosis; ultrasound; applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; R & D incentives; tissue characterization; tissue signature; *SP453*, pp. 7-10 (Oct. 1976).

Ultrasonic inspection; aircraft component failure; continuous wave holograms; crack detection; holographic techniques; pulsed laser holograms; stress corrosion cracking; *SP423*, pp. 93-103 (Apr. 1976).

Ultrasonic measurements; ultrasonic techniques; calibration; diagnostic ultrasound; *SP456*, pp. 91-97 (Nov. 1976).

Ultrasonic medicine; ultrasonic radiation; optical interferometric measurements; *SP456*, pp. 285-297 (Nov. 1976).

Ultrasonic power measurements; calorimeter; ultrasonic calorimeter; *TN686*.

Ultrasonic radiation; optical interferometric measurements; ultrasonic medicine; *SP456*, pp. 285-297 (Nov. 1976).

Ultrasonic reference blocks; acoustic emission; aluminum; fatigue cracks; flat bottomed holes; standards; steel; titanium; transducer calibration; *16252*.

Ultrasonic spectroscopy; ultrasound; velocity; absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; tumor; *SP453*.

Ultrasonic spectroscopy; ultrasound diagnosis; acoustic impedance; Bragg diffraction; computer processing; frequency-dependent attenuation; internal scattering; myocardial infarction; scattering; surface scattering; tissue characterization; *SP453*, pp. 167-196 (Oct. 1976).

Ultrasonic techniques; calibration; diagnostic ultrasound; ultrasonic measurements; *SP456*, pp. 91-97 (Nov. 1976).

Ultrasonic wire bonding; voltage contrast mode; x-ray photoelectron spectroscopy; acoustic emission; Auger electron spectroscopy; beam-lead bonds; bias-temperature stress test; boron redistribution; capacitance-voltage methods; dopant profiles; electrical properties; *SP400-25*.

Ultrasonics; aluminum ultrasonic reference standards; ASTM-type reference standards; calibration; interim reference standard; longitudinal beam; measurement system; nondestructive evaluation; pulse-echo; *TN924*.

Ultrasonics; aluminum ultrasonic standards; ASTM-type reference standards; calibration; fabrication variables; immersion testing; interim reference standard; longitudinal waves; metallurgical variables; nondestructive evaluation; pulse echo; steel ultrasonic standards; *NBSIR 76-984*.

Ultrasonics; A-scan; attenuation; computer analysis; impedance; liver cirrhosis; *SP453*, pp. 61-70 (Oct. 1976).

Ultrasonics; bulk modulus; equation of state; high pressure; phase transitions; potassium chloride; *16029*.

Ultrasonics; electroacoustics; medical diagnostics; radiation safety; radiation therapy (ultrasonic); *NBSIR 75-937*.

Ultrasonics; electromagnetic transducer; EMAT; transducer; *16616*.

Ultrasonics; velocity; absorption; attenuation; impedance gradient; transient thermal gradients; *SP453*, pp. 143-151 (Oct. 1976).

Ultrasonics; x-radiography; end fitting; glass-reinforced-plastic rod end fitting; nondestructive examination; neutron radiography; *NBSIR 76-1084*.

Ultrasound; acoustic attenuation; acoustic velocity; breast tumor; computerized tomography; heart; reconstruction; refractive index; synthetic focus; tissues; *SP453*, pp. 109-119 (Oct. 1976).

Ultrasound; analog-digital converter; A-scan; digitization; pattern recognition; speech spectrogram; *SP453*, pp. 51-59 (Oct. 1976).

Ultrasound; angular dependence; blood; compressibility; density; distribution function; erythrocytes; hematocrit; scattering; *SP453*, pp. 207-212 (Oct. 1976).

Ultrasound; applied research; imaging; instrumentation technology; medical ultrasonics; NSF; RANN; R & D incentives; tissue characterization; tissue signature; ultrasonic diagnosis; *SP453*, pp. 7-10 (Oct. 1976).

Ultrasound; attenuation; computer; deconvolution; impedance; impulse response; layer model; lucite; *SP453*, pp. 231-251 (Oct. 1976).

Ultrasound; blood; cross-section; diagnosis; scattering; standardization; tissue characterization; *SP453*, pp. 29-47 (Oct. 1976).

Ultrasound; Bragg diffraction; diagnosis; frequency dependence; orientation dependence; scattering; tissue characterization; *SP453*, pp. 197-206 (Oct. 1976).

Ultrasound; color-coded B-scan; Fourier transform; spectral analysis; tissue structure; *SP453*, pp. 97-107 (Oct. 1976).

Ultrasound; diagnosis; Doppler effect; optimization; resonance; scattering; tissue characterization; tissue parameters; tumor detection; *SP453*, pp. 11-17 (Oct. 1976).

Ultrasound; diffraction; Fourier transform; scattering; tissue characterization; *SP453*, pp. 213-228 (Oct. 1976).

Ultrasound; velocity; absorption; acoustic; A-scan; attenuation; B-scan; frequency; image; impedance; medical diagnosis; microscopy; pattern recognition; reconstruction; scattering; tissue characterization; tissue parameters, tissue signature; tumor; ultrasonic spectroscopy; *SP453*.

Ultrasound; velocity; absorption; attenuation; mammalian tissues; tissue parameters; *SP453*, pp. 21-28 (Oct. 1976).

Ultrasound; velocity; acoustic imaging; acoustic microscopy; attenuation; frequency dependence; impedance; microstructural analysis; tissue; *SP453*, pp. 261-267 (Oct. 1976).

Ultrasound; velocity; attenuation; breast tissue; broadband; high resolution; imaging; large aperture; pathology; pellicle; phase-contrast; transmission; *SP453*, pp. 121-133 (Oct. 1976).

Ultrasound; velocity; attenuation; breast; reflection techniques; *SP453*, pp. 135-139 (Oct. 1976).

Ultrasound diagnosis; acoustic impedance; Bragg diffraction; computer processing; frequency-dependent attenuation; internal scattering; myocardial infarction; scattering; surface scattering; tissue characterization; ultrasonic spectroscopy; *SP453*, pp. 167-196 (Oct. 1976).

Ultratrace level; accuracy; analysis of precision; *a priori* error; *a priori* precision; *a posteriori* precision; chi-square test; precision; precision of analytical method; *SP422*, pp. 127-139 (Aug. 1976).

Ultraviolet; absorption; B-stars; C IV; O-stars; Si IV; spectra; stellar; *16271*.

Ultraviolet; detectors; NBS; radiometry; sources; standards; survey; *SP456*, pp. 107-110 (Nov. 1976).

Ultraviolet; uniformity of response; detector; photodiode; silicon; *16413*.

Ultraviolet; visible; averaging sphere; diffusing effectiveness; efficiency; fluorescent wavelength converter; photometry; spectrophotometry; *16333*.

Ultraviolet; wavelength; zirconium; molybdenum; niobium; spectra; *16425*.

Ultraviolet; wavelength calibration; averaging spheres; high accuracy transmittance; light averaging devices; linearity; photometric precision; reference spectrophotometer; *TN913*.

Ultraviolet; wavelengths; barium; cesium; lanthanum; spectra; *16035*.

Ultraviolet; wavelengths; iron; spectra; *16133*.

Ultraviolet; wavelengths; yttrium; spectra; *15725*.

Ultraviolet; wavelengths; yttrium; zirconium; spectra; *16134*.

Ultraviolet absorbance standards; absorbance linearity; accuracy; acidic potassium dichromate solutions; calibration of ultraviolet spectrophotometers; liquid filters; transfer standards; *J. Res.* **80A** No. 4, 631-636 (1976).

Ultraviolet and visible spectroscopy; aromatic amine; benzene derivative; charge-transfer complex; dental materials; electron affinity; electron spin resonance spectroscopy; extrathermodynamic relationships; ionization potential; *J. Res.* **80A** No. 2, 173-187 (1976).

Ultraviolet averaging sphere; ultraviolet to visible converter; averaging sphere; averaging ultraviolet and visible light; radiation converter; *U.S. Patent 3,968,363*.

Ultraviolet detectors; detection; fire detectors; flame detectors; heat detectors; infrared detectors; smoke detectors; testing; *NBSIR 76-1040*.

Ultraviolet laser action; He-Ag and Ne-Ag mixtures; laser action; *16511*.

Ultraviolet laser, 250.0 nm; Cu II spectrum; *16192*.

Ultraviolet photoelectron spectroscopy; x-ray photoelectron spectroscopy; adsorbate; chemisorption; ruthenium; *15814*.

Ultraviolet photoelectron spectroscopy; virgin CO; adsorption; carbon monoxide; chemisorption; desorption; photoelectron spectroscopy; photoemission; single crystal; tungsten; *15851*.

Ultraviolet photoelectron spectroscopy (UPS); angle and energy distributions; charged particle spectroscopy; electron-stimulated desorption of ions (ESDIAD); field-ion microscopy (FIM); low energy electron diffraction (LEED); *16078*.

Ultraviolet photoemission; adsorption; chemisorption; CO; cyclotron resonance; electron cyclotron resonance; magnetic field; microwave discharge; photoemission; tungsten; *16016*.

Ultraviolet photoemission; valence band; virgin states; α states; β states; adsorption; carbon; carbon monoxide; chemical bonding; chemisorption; density dependent transitions; desorption; dissociative adsorption; electronic states; hydrogen; monolayers; nitrogen; *16419*.

Ultraviolet radiation; weatherability; antenna-support materials; environmental degradation; guys, nonmetallic; marine atmospheres; plastics, fiber-reinforced; pultrusions; stress-rupture testing; sunlight; *NBSIR 76-1069*.

Ultraviolet, spectra; atomic processes; sun, corona; sun, flares; sun, prominences; sun, spectra; *15987*.

Ultraviolet, spectra; stars, chromospheres; stars, late type; *16031*.

Ultraviolet spectrum; Ar metastable interactions; $ClHCl^-$; emission spectrum; HAr_n^+; $HCCl_2^+$; $HCCl_2^-$; $HCCl_3$; infrared spectrum; matrix isolation; molecular rotation in solid Ar; photoinduced proton transfer; *15757*.

Ultraviolet spectrum-sun; chromosphere-sun; coronal holes; diffusion; transition region-sun; *15717*.

Ultraviolet stellar spectra; Wilson-Bappu effect; chromospheres, stellar; *Copernicus* observations; *15784*.

Ultraviolet to visible converter; averaging sphere; averaging ultraviolet and visible light; radiation converter; ultraviolet averaging sphere; *U.S. Patent 3,968,363*.

Ultraviolet-visible filters; evaporated metal-on-quartz; filters, transmittance; neutral filters; standard reference materials; transmittance characteristics; *J. Res.* **80A** No. 4, 637-641 (1976).

Unbalance; vibration; diesel-electric sets; gears; looseness; signature analysis; *NBS-GCR-74-22*.

Uncertainties; accuracy; optical radiation measurement; radiometry; systematic errors; *16583*.

Uncertainties; crystallographic data; errors; probability plots; residuals; statistics; *NBSIR 76-1102*.

Uncertainty; autocollimator; calibration; constant deviation prism; geometrical model; optical square; pentaprism; reflection; refraction; standard deviation; *NBSIR 76-993*.

Uncertainty; calibration; diameter; gravitational bending; interferometry; least squares line; linear model; optical flat; profile; standard deviation; *NBSIR 75-975*.

Uncertainty; creep; fire endurance; fire tests; reinforced concrete; sensitivity analysis; steel; structural mechanics; *BSS76*.

Uncertainty; measurement; measurement assurance; *15976*.

Uncertainty; measurement; traceability; *15975*.

Uncertainty; water phantom; absorbed dose; cobalt-60 gamma radiation; computation check; dose interpretation; mailings; results; therapy departments; thermoluminescence dosimeters; *J. Res.* **80A** No. 4, 663-668 (1976).

Underground; alloys; corrosion; metallurgically-bonded; metals; plastic-bonded; soils; telephone cables; *16352*.

Underground; corrosion; galvanic; hydrogen embrittlement; soil; stainless steel; stress; stress-corrosion; *16354*.

Underground corrosion; copper; corrosion; galvanic corrosion; soil corrosion; stainless steel; *16355*.

Underground corrosion; metal and plastic composites; metal composites, metals; soil corrosion, telephone cable shields; *16351*.

Underlayments; carpets; fire; flammability; floor coverings; pad; *NBSIR 76-1018*.

Underplatings for gold; wear of gold; contact lubrication; corrosion inhibitors; electrical contacts; gold plate; palladium; polymer in gold; porosity in gold; solder plate; tin-nickel alloy; tin plate; *SP452*, pp. 64-71 (Sept. 1976).

Underpotential deposition; electrocatalysis; foreign metal monolayers; Fe^{2+}/Fe^{3+} reaction; formic acid oxidation; oxygen reduction; *SP455*, pp. 191-200 (Nov. 1976).

Uniform approximation; chemical reactions; classical scattering matrix theory; collision theory; hydrogen atoms; hydrogen molecules; scattering theory; trajectories; *16054*.

Uniform asymptotic approximations; Weber's equation; error bounds; parabolic cylinder functions; turning points; *J. Res.* **80B** No. 4, 437-440 (1976).

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Water sampling; contamination; geological sample; rocks and minerals; sample preparation; sampling; trace analysis; *SP422,* pp. 285-297 (Aug. 1976).

Water sampling apparatus; anodic stripping voltammetry; flameless atomic absorption; interstitial water; Lake Superior chemical analysis; trace element water analysis; water filtration; *SP422,* pp. 1073-1088 (Aug. 1976).

Water spray; automatic sprinkler; corridor sprinkler systems; discharge patterns; spray distribution; water distribution; *NBSIR 75-920.*

Water spray; automatic sprinklers; bibliography; droplet size; fire suppression; spray nozzles; spray patterns; test methods; water distribution; *NBS-GCR-76-72.*

Water supply; backflow; backflow preventers; back pressure; back-siphonage; cross connections; health hazard; potable water; vacuum breaker; *NBSIR 76-1070.*

Water tight; bridge; deep-sea thermometer; high pressure; oceanographic thermometer; platinum resistance thermometer; pressure; pressure intensifier; pressure seal; pressure vessel; resistance; resistance thermometer; test; thermometer; thermometer leads; thermostated bath; *TN894.*

Water vapor; humidity; humidity measurement system; measurement of humidity; measurement of moisture; moisture; moisture measurement system; *NBSIR 75-933.*

Waters, lead in; accuracy of atomic absorption analytical techniques; accuracy of isotope dilution analytical techniques; errors in lead analyses; lead; lead contamination evaluation and control; lead in animals and plants; pollution, lead; *SP422,* pp. 321-351 (Aug. 1976).

Watthour meter; electric energy; electricity; electric power; measurement assurance; transport standard; *TN930.*

Watthour meters; code; definitions; demand meters; electricity metering; performance requirements; standards; test methods; *15829.*

Wave equations; causality; high spin fields; inhomogeneous Lorentz group; relativistic fields; *Monogr. 154.*

Wave functions; ions; oscillator strengths; quantum mechanics; spectroscopy; transition probabilities; *16209.*

Waveform distortion; alkali-halides; alkaline-earth fluorides; bulk damage; focal spot diameter; inclusion damage; interference ripples; pulsed DF laser damage; sapphire; scattering; *SP462,* pp. 136-144 (Dec. 1976).

Waveform distortion; ZnSe; KCl; NaCl; pulsed CO_2 TEA laser damage; transmitted pulse; *SP435,* pp. 107-117 (Apr. 1976).

Wave-guide boundary problem; analytic function; Cauchy principle value; Hilbert problem for two unknowns; singular integral equation; *J. Res.* **80B** No. 3, 403-414 (1976).

Waveguide-below-cutoff; absolute (unambiguous) readout; piston; precision attenuator; sensor; *NBSIR 76-833.*

Wavelength; zirconium; molybdenum; niobium; spectra; ultraviolet; *16425.*

Wavelength accuracy; bandwidth; calibration; errors in spectrophotometry; interferences; multiple reflections; photometric linearity; polarization; sample characteristics; straylight; *J. Res.* **80A** No. 4, 609-624 (1976).

Wavelength calibration; averaging spheres; high accuracy transmittance; light averaging devices; linearity; photometric precision; reference spectrophotometer; ultraviolet; *TN913.*

Wavelength comparison; interferometer; laser; optical frequency; optical heterodyne; *15887.*

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Wavelengths; iron; spectra; ultraviolet; *16133.*

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Wavelengths; yttrium; zirconium; spectra; ultraviolet; *16134.*

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Wax-bound electrode; amperometry; cyclic voltammetry; electrosorption; Langmuir; lead dioxide; pyrophosphate; Temkin; *SP455,* pp. 183-189 (Nov. 1976).

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Waybills; railroad freight movements; short-line miling system; *16241.*

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Wear; castable refractories; coal gasification; deformation; erosion; fracture; *16600.*

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Wear; composite resins; composites; dental materials; fillers; porous glass; radiopacity; reinforcements; *16586.*

Wear; composite resins; composites; dental materials; fillers; porous glass; radiopacity; reinforcements; *16587.*

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Wear; corrosion; crack-free chromium; electroplating; fast plating; fatigue strength; grinding; hardness; stress; tensile strength; *SP452,* pp. 56-63 (Sept. 1976).

Wear; curing agent; fretting; silicone resin; solid lubricants; titanium; *SP452,* pp. 124-131 (Sept. 1976).

Wear; economic savings of failure prevention; friction; lubrication; mechanical failure; tribology; *SP423,* pp. 117-139 (Apr. 1976).

Wear; electron channeling; iron; metals; plastic deformation; surfaces; *16523.*

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Wear; fluoride films; gears; molybdenum disulfide; solid lubricants; *SP452,* pp. 132-148 (Sept. 1976).

Wear; wear debris; x-ray analysis; copper; electron channeling; electron microscope; metals; particle analysis; plastic deformation; surfaces; *NBSIR 76-1141.*

Wear; wear testing; erosive wear; particle impingement; particle velocity measurement; *15778.*

Wear debris; x-ray analysis; copper; electron channeling; electron microscope; metals; particle analysis; plastic deformation; surfaces; wear; *NBSIR 76-1141.*

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Wear resistant alloy; auto-catalytic nickel; auto-catalytic nickel, hardness of; auto-catalytic nickel, wear of; electroless nickel; electroless nickel, hardness of; electroless nickel, wear of; nickel, auto-catalytic; nickel, electroless; *SP452,* pp. 45-55 (Sept. 1976).

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Web reinforcement; column; ductility; earthquake; reinforced concrete; shear tests; structural engineering; *SP444,* pp. IV-16—IV-36 (Apr. 1976).

Weber's equation; boundary-value problem; eigenvalues; parabolic cylinder functions; resonance; rotating disks; singular perturbations; turning-point; viscous flow; *16459.*

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Welding; fracture control; fracture mechanics; mechanical properties; nondestructive evaluation (NDE); radiography; *NBSIR 76-1154, Vol. 2.*

Wet ashing; ashing techniques; dissolution; dry ashing; organic materials analysis; trace element analysis; *SP422,* pp. 491-507 (Aug. 1976).

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Wet pavement; accident reduction, skidding; correlation, skid resistance; highway safety; pavement, skid resistance; pavement wetting system, tire-pavement interface forces; *NBSIR 75-972.*

Wet pavement; accident reduction, skidding; correlation, skid resistance; highway safety; measurement, skid resistance; pavement, skid resistance; pavement wetting system; tire-pavement interface forces; *NBSIR 76-1133.*

Wet-ashing blank; biological analysis; container blank; neutron activation analysis; *SP422,* pp. 593-604 (Aug. 1976).

Wheatstone Bridge; automatic network analyzers; computer-controlled measurement; magic tee; microwave measurement methods; multiple probe devices; reflectometers; rotating probe devices; slotted lines; survey of automatic techniques; swept frequency measurements; *Monogr. 151.*

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Wind; bridges; buildings; codes; disaster; dynamic analysis; earthquakes; modeling; soils; structural response; volcanoes; *SP444.*

Wind; buildings; cyclones; disasters; structural engineering; tides; *BSS86.*

Wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; *NBS-GCR-75-36.*

Wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; *NBS-GCR-75-37.*

Wind; buildings; damage; disaster; dynamic analysis; earthquakes; hurricanes; natural hazards; structural engineering; tornados; *NBS-GCR-75-38.*

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Wind; wind damage; wind engineering; building codes; design standards; masonry construction; roofs; siding; structural engineering; *TN909.*

Wind; wind intensities; cloud seeding; frequency distribution; hurricanes; typhoon; *SP444,* pp. I-21—I-33 (Apr. 1976).

Wind damage; wind engineering; building codes; design standards; masonry construction; roofs; siding; structural engineering; wind; *TN909.*

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Wind load; finite element; guyed tower; structural analysis; structural engineering; vibration analysis; *SP444*, pp. IV-37—IV-54 (Apr. 1976).
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Wind loads; buildings; codes and standards; housing; hurricanes; low-rise buildings; natural disaster; structural connections; typhoons; *NBSIR 75-790*.
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Wind tunnels; aerodynamics; boundary layers; buildings; codes and standards; wind loads; *SP444*, pp. II-21—II-51 (Apr. 1976)
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Window damage; mirror damage; pulsed lasers; *SP435*, pp. 202-206 (Apr. 1976).
Windows; daylight gathering; daylighting of buildings; energy conservation; lenses; light conduits; light control; reflectors; skylights; *NBSIR 76-1098*.
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X band; cavity stabilization; frequency multiplication; frequency stability; frequency synthesis; Gunn oscillator; infrared; injection stabilization; klystron; *16520*.
χ particles; angular distributions; gamma-gamma correlations; quark models; symmetries; ψ particles; *15962*.
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X-ray analysis; copper; electron channeling; electron microscope; metals; particle analysis; plastic deformation; surfaces; wear; wear debris; *NBSIR 76-1141.*

X-ray analysis; electron microscopy; Fe-Cr alloys; passive films; pitting corrosion; stainless steel; *16024.*

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X-ray fluorescence; accuracy; anodic stripping voltammetry; arc emission spectroscopy; atomic absorption; environmental analyses; interlaboratory tests; neutron activation analysis; plasma emission; round robin; *SP422,* pp. 199-210 (Aug. 1976).

X-ray fluorescence; accuracy; atomic absorption; environment; neutron activation analysis; precision; *SP422,* pp. 239-245 (Aug. 1976).

X-ray fluorescence; atmospheric particulates; direct analysis techniques; emission spectroscopy; particulate analysis; particulate characterization; sampling methods; *SP422,* pp. 791-803 (Aug. 1976).

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X-ray generators; x rays; calibration; electrical measurements; electro-optics; frequency response; high voltage; Kerr effect; operational amplifier; pulses; radiation; safety; *NBSIR 75-775.*

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X-ray trends; diagnostic; nationwide evaluation; physician; technologist; x-ray departments; *SP456*, pp. 147-152 (Nov. 1976).

X-ray tube potential; attenuation; exposure; phantoms; phototiming; radiographic examination; *SP456*, pp. 381-388 (Nov. 1976).

X-ray units; computer power; computer standard; corrosion; environment; health care; housing production; I-R 100 awards; NIKE missile; papers available; stereology; toy safety; *DIM/NBS* **60**, No. 11, 1-24 (1976).

X-ray, zwitterion; hydrogen bonding; single crystal; structure determination; *S*-carboxymethyl-L-cysteine sulfone; *16565*.

Y

Yagi; antenna; director; driven element; gain; radiation pattern; reflector; *TN688*.

Yield point; biaxial; fatigue; fracture; laboratory automation; mechanical testing; plasticity; polyvinyl chloride; servohydraulic system; viscoelasticity; *16626*.

Youden plot; analytical performance; between-run; calibration; precision; quality control; systematic error; *SP422*, pp. 141-150 (Aug. 1976).

Youden plot; Youden squares; Youden, W. J; calibration designs; chain blocks; collaborative tests; diagnostic tests, index for rating; experiment design, statistical; graphical diagnosis; interlaboratory tests; randomization, constrained; ruggedness test; *16115*.

Youden squares; Youden, W. J; calibration designs; chain blocks; collaborative tests; diagnostic tests, index for rating; experiment design, statistical; graphical diagnosis; interlaboratory tests; randomization, constrained; ruggedness test; statistical techniques; *16115*.

Youden, W. J; calibration designs; chain blocks; collaborative tests; diagnostic tests, index for rating; experiment design, statistical; graphical diagnosis; interlaboratory tests; randomization, constrained; ruggedness test; statistical techniques; Youden plot; *16115*.

Young modulus; bulk modulus; compressibility; Debye temperature; elastic constants; plutonium; plutonium alloy; Poisson ratio; shear modulus; sound velocity; *16635*.

Young's modulus; bulk modulus; composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; shear modulus; *16264*.

Young's modulus; bulk modulus; compressibility; copper; copper alloys; elastic constants; Poisson ratio; pulse-echo method; resonance method; shear modulus; sound velocity; *16505*.

Young's modulus; composite materials; elastic constants; filled polymers; mechanical properties; particulate composites; Poisson's ratio; *J. Res.* **80A** No. 1, 45-49 (1976).

Ytterbium; bismuth; gold; hafnium; ionization energies; iridium; lead; lutetium; mercury; osmium; platinum; rhenium; tantalum; thallium; tungsten; wavelengths; *16420*.

Ytterbium; energy levels; spectrum; wavelengths; *15920*.

Yttrium; spectra; ultraviolet; wavelengths; *15725*.

Yttrium; zirconium; spectra; ultraviolet; wavelengths; *16134*.

Z

Zeeman effect; atomic beam; autoionization; differential metastability; fine structure; inner shell excitation; rf spectroscopy; rubidium; *16098*.

Zeeman effect, Hf I; analysis, Hf I spectrum; hafnium, analysis of first spectrum; spectrum, Hf I; *Monogr. 153*.

Zeeman-effect of Th I; energy levels; thorium; Th I; wavelengths; *J. Res.* **80A** No. 2, 221-358 (1976).

Zero phonon line; charge transfer, color centers; crystal field; d^4 ions; EPR; iron 4+; optical absorption; perovskite; strontium titanate; transition metal; *16201*.

Zero shift; calibration; dynamic; electronic flash; photographic flashbulb; pressure; pressure measurement; pressure transducer; thermal transient; transducer; *TN905*.

Zero shift; calibration; dynamic; electronic flash; photoflash bulb; pressure; pressure measurement; pressure transducer; pressure transducer response; response; thermal transient; transducer; *NBSIR 76-1038*.

Zero shift; coatings; dynamic; dynamic response; pressure transducer; protective coatings; shock tube; tape; thermal radiant-energy response; thermal transient response; transducers; *NBSIR 76-1144*.

Zimm theory; bead-spring model; block copolymers; dilute polymer solutions; limiting viscosity number; Mandelkern-Flory-Scheraga equation; molecular weight determination; sedimentation coefficient; translational diffusion coefficient; *16026*.

Zinc; Adriatic Sea; cadmium; copper; electrochemical analysis; heavy metals; lead; seawater analysis; speciation; stability of water samples; *SP422*, pp. 917-928 (Aug. 1976).

Zinc; alloys; aluminum; catalysis; hydrogenation; iron; Mössbauer spectra; *16537*.

Zinc; atomic absorption; cadmium; copper; lead; manganese; sensitivity; spectrophotometry; statistical methods; *SP422*, pp. 1023-1033 (Aug. 1976).

Zinc; atomic absorption spectrophotometry; calcium; container effects; copper; magnesium; potassium; serum minerals; serum storage effects; sodium; temperature effects; trace elements; *SP422*, pp. 575-591 (Aug. 1976).

Zinc oxide; dislocation; electrochemical; exchange current; semiconductor; traps; *SP455*, pp. 139-148 (Nov. 1976).

Zinc point; comparator; International Practical Temperature Scale of 1968; IPTS-68; oxygen point; platinum resistance thermometer; temperature standard; tin point; triple point of water; *J. Res.* **80A** No. 3, 477-504 (1976).

Zinc selenide; copper; molybdenum; optician; polishing; surfaces; *SP435*, pp. 10-13 (Apr. 1976).

Zinc selenide; refractive index; temperature coefficient of refractive index; *SP435*, pp. 170-174 (Apr. 1976).

Zinc selenide coatings; laser antireflective coatings; materials purification requirements; pulsed laser damage; rare earth fluorides; *SP462*, pp. 271-278 (Dec. 1976).

Zinc selenide window; computer analysis; laser induced stresses; stress analysis; thermal analysis; *SP462*, pp. 29-35 (Dec. 1976).

Zirconium; field-ion microscopy; *16466*.

Zirconium; molybdenum; niobium; spectra; ultraviolet; wavelength; *16425*.

Zirconium; spectra; ultraviolet; wavelengths; yttrium; *16134*.

ZnS; CeF_3; CO_2 pulsed laser damage; coating topography; KCl; laser window coatings; *SP435*, pp. 236-243 (Apr. 1976).

ZnSe; BaF_2; CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; thermal coefficient of refractive index; thermal expansion coefficient; *SP462*, pp. 58-63 (Dec. 1976).

ZnSe; BaF_2; CaF_2; fused silica; interferometry; photoelasticity; piezo-optic constants; refractive index; thermal coefficient of refractive index; thermal expansion coefficient; *NBSIR 76-1115*.

ZnSe; chemical vapor deposited ZnSe; elastic compliance; elastic constants; polycrystalline ZnSe; refractive index; stress-optic constants; temperature coefficient of index; thermal expansion; *15938*.

ZnSe; CO_2 laser radiation; Cu; CW laser damage; grating; infrared windows; KCl; mirror; Mo; NaCl; window; *SP435*, pp. 189-201 (Apr. 1976).

ZnSe; far field intensity; laser windows; thermal distortion; thermal lensing; *SP435*, pp. 142-147 (Apr. 1976).

ZnSe; KCl; NaCl; pulsed CO_2 TEA laser damage; transmitted pulse; waveform distortion; *SP435*, pp. 107-117 (Apr. 1976).

ZnSe; 10.6 μm; absorbing inclusions; damage statistics; laser damage; reflectors; ThF_4; thin film; *SP435*, pp. 216-229 (Apr. 1976).

Zoning; building codes; building laws and regulations; building materials—testing and evaluation; building systems; industrialized housing; mobile homes; modular construction; prefabrication; *NBS-GCR-73-19*.

Zwanzig-Mori formalism; hydrodynamic regime; ideal gas memory function; limit of stability; metastable fluid states; nonhydrodynamic regime; relaxation time; transport coefficients; *16601*.

1^{--} states; e^+e^- annihilation; exotic mesons; meson classification; ψ and χ particles; *15961*.

(100) surface of copper; heat transfer to helium II; interfacial thermal resistance; Kapitza conductance; Kapitza conductance of copper; x-ray diffraction examination of single crystal lattice damage; *15737*.

10^{-3} to 10^{-4} torr range; pressure generation; *16028*.

10.6 μm; absorbing inclusions; damage statistics; laser damage; reflectors; ThF_4; thin film; ZnSe; *SP435*, pp. 216-229 (Apr. 1976).

10.6 μm; As_2S_3; coating deposition; index of refraction; laser windows; surface composition; *SP435*, pp. 244-247 (Apr. 1976).

10.6 μm absorption; 10.6 μm optical components; dielectric coatings; infrared laser windows; laser heating of metal surfaces; laser mirrors; pulsed CO_2 laser damage; surface damage; *SP462*, pp. 181-188 (Dec. 1976).

10.6 μm laser; damage theory; laser damage; *SP462*, pp. 371-378 (Dec. 1976).

10.6 μm laser; diamond turning; KCl laser windows; laser damage; *SP462*, pp. 149-157 (Dec. 1976).

10.6 μm lasers; coatings; laser damage; laser windows; *SP462*, pp. 264-278 (Dec. 1976).

10.6 μm optical components; dielectric coatings; infrared laser windows; laser heating of metal surfaces; laser mirrors; pulsed CO_2 laser damage; surface damage; 10.6 μm absorption; *SP462*, pp. 181-188 (Dec. 1976).

1.06 μm polishing; copper mirror; damage threshold; dark field photography; diamond turned optics; *SP435*, pp. 29-40 (Apr. 1976).

^{129}I; beta; coincidence counting; gamma; radioactivity; standardization; *16259*.

^{13}C; alkane; chemical shift tensor; methylene; NMR; *16041*.

^{13}C magnetic resonance; collagen; conformation; correlation times; cyanogen bromide peptides; polypeptides; relaxation times; rotational diffusion; *16211*.

1,3-dithiolane-2-thione; 1,3-dithiolene-2-thione; carbon-13 NMR; coordination compounds; metal carbonyl; thiocarbonyl; *16585*.

1,3-dithiolenes; ^{31}P NMR; 4,5-dicyano-1,3-dithiolene-2-thione; aryl phosphines; cyclic voltammetry; desulfurization; phosphines; tetracyanotetrathiafulvalene; tetracyanotetrathiafulvalene·triphenylphosphine; *15991*.

1,3-dithiolene-2-thione; carbon-13 NMR; coordination compounds; metal carbonyl; thiocarbonyl; 1,3-dithiolane-2-thione; *16585*.

1,3-dithiolene-2-thione; chromium carbonyl; infrared spectroscopy; metal carbonyl; molybdenum carbonyl; NMR spectroscopy; *15985*.

1,6-diphenyl-1,3,5-hexatriene; fluorescence; linear dichroism; liquid crystals; polarization; spectrofluorimetry; *J. Res.* **80A** No. 1, 15-33 (1976).

^{161}Dy; amorphous; magnetization; metal; Mössbauer; ^{57}Fe; *16403*.

^{186}, ^{187}Os(n,γ); $E_n = 25$ keV; measured cross-section ratio; nuclear reactions; *16579*.

2-butanone (methyl ethyl ketone); enthalpy; entropy; equilibrium constant of formation; Gibbs energy of formation; heat capacity; ideal gas thermodynamic properties; internal rotational barrier height; propanone (acetone); *JPCRD* **5**, No. 2, 319-328 (1976).

2-connected; block-cutpoint tree; graph; tree; *16154*.

2-hydroxy-2′,4′,4-trichlorodiphenyl ether; bacteriostats; blood analysis; gas chromatography; trace analysis; triclosan; *SP422*, pp. 851-859 (Aug. 1976).

2-methyl propene; carbon isotopes; carbonyl fluoride; CO_2 laser photolysis; difluorocarbene; difluorodichloromethane; isotope ratio; nitric oxide; oxygen; tetrafluoroethylene; transverse excitation laser; *16657*.

2,3-dimethylbutanol-2; 3,3-dimethylbutanol-2; alcohols; heats of formation; hydroxy-alkyl radicals; shock tube; thermal decomposition; *15904*.

^{239}Pu track; alpha particle tracks; fission radiography; solid dielectric track recorders; *SP422*, pp. 1132-1142 (Aug. 1976).
2,4-dichlorophenol; 2,4-dichlorophenoxyacetic acid; gas chromatography; potatoes; residues, dissipation of; residues, in potatoes; residues, metabolic; residues, total; residues, volatilization; storage effects; *SP422*, pp. 737-745 (Aug. 1976).
2,4-dichlorophenoxyacetic acid; gas chromatography; potatoes; residues, dissipation of; residues, in potatoes; residues, metabolic; residues, total; residues, volatilization; storage effects; 2,4-dichlorophenol; *SP422*, pp. 737-745 (Aug. 1976).
285-nm radiation; 480-nm radiation; absolute cross sections; electron impact; mercury ions; *16588*.
3-methyl sulfolane; pyrolysis; SO_2; trimethylene sulfone; *15952*.
^{31}P NMR; 4,5-dicyano-1,3-dithiolene-2-thione; aryl phosphines; cyclic voltammetry; desulfurization; phosphines; tetracyanotetrathiafulvalene; tetracyanotetrathiafulvalene·triphenylphosphine; $\Delta^{2,2'}$-bis-14.5-dicyano-1,3-dithiodene; *15991*.
3,3-dimethylbutanol-2; alcohols; heats of formation; hydroxyalkyl radicals; shock tube; thermal decomposition; 2,3-dimethylbutanol-2; *15904*.
3.5 percent NaCl; 7XXX aluminum alloys; Aluminum Association; ASTM; industrial atmosphere; round robin tests; seacoast atmosphere; standard; stress-corrosion; *16656*.
^{37}Ar; atmospheric mixing; atmospheric radioactivity; cosmic ray reactions; isotopic enrichment; *16388*.
4*d* photoabsorption; atomic structure; barium; N_{IV} edges; spectroscopy; vacuum ultraviolet; *15845*.
4*f* electron excitations; photoelectron spectroscopy; rare earth metals; *15841*.
4,5-dicyano-1,3-dithiolene-2-thione; aryl phosphines; cyclic voltammetry; desulfurization; phosphines; tetracyanotetrathiafulvalene; tetracyanotetrathiafulvalene·triphenylphosphine; $\Delta^{2,2'}$-bis-14.5-dicyano-1,3-dithiodene; 1,3-dithiolenes; *15991*.
480-nm radiation; absolute cross sections; electron impact; mercury ions; 285-nm radiation; *16588*.
5*f* electron; actinium; excitation energy; *U; 16581*.
$^{5}\Sigma_g^{+}$; electronic structure; energy curve; N_2; predissociation; radiative recombination; *16442*.
^{57}Fe; ^{161}Dy; amorphous; magnetization; metal; Mössbauer; *16403*.
6-port junction; power meter; *16568*.
7XXX aluminum alloys; Aluminum Association; ASTM; industrial atmosphere; round robin tests; seacoast atmosphere; standard; stress-corrosion; 3.5 percent NaCl; *16656*.

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APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

Alexander City: Alexander City State Junior College, Thomas D. Russell Library (1967).
Auburn: Auburn University, Ralph Brown Draughon Library (1907).
Birmingham:
- Birmingham Public Library (1895).
- Birmingham-Southern College Library (1932).
- Jefferson State Junior College, James B. Allen Library (1970).
- Samford University, Harwell G. Davis Library (1884).

Enterprise: Enterprise State Junior College Library (1967).
Florence: University of North Alabama, Collier Library (1932).
Gadsden: Gadsden Public Library (1963).
Huntsville: University of Alabama, Huntsville Campus Library (1964).
Jacksonville: Jacksonville State University, Ramona Wood Library (1929).
Maxwell A.F. Base: Air University Library (1963).
Mobile:
- Mobile Public Library (1963).
- Spring Hill College, Thomas Byrne Memorial Library (1937).
- University of South Alabama Library (1968).

Montgomery:
- Alabama State Department of Archives and History Library (1884).
- Alabama Supreme Court Library (1884).
- Auburn University at Montgomery Library (1971)—REGIONAL.

Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
St. Bernard: St. Bernard College Library (1962).
Troy: Troy State University, Lurleen B. Wallace Educational Resources Center (1963).
Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
University:
- University of Alabama, School of Law Library (1967).
- **University of Alabama Library (1860)—REGIONAL.**

ALASKA

Anchorage:
- Anchorage Higher Education Consortium Library (1961).
- Supreme Court of Alaska Library (1973).

College: University of Alaska, Elmer E. Rasmuson Library (1922).
Juneau: Alaska State Library (1964).
Ketchikan: Ketchikan Community College Library (1970).

ARIZONA

Coolidge: Central Arizona College, Instructional Materials Center (1973).
Flagstaff: Northern Arizona University Library (1937).
Phoenix:
- Department of Library and Archives (unknown)—REGIONAL.
- Phoenix Public Library (1917).

Prescott: Yavapai College Library (1976).
Tempe: Arizona State University, Matthews Library (1944).
Thatcher: Eastern Arizona Junior College Library (1963).
Tucson:
- Tucson Public Library (1970).
- University of Arizona Library (1907)—REGIONAL.

Yuma: Yuma City-County Library (1963).

ARKANSAS

Arkadelphia: Ouachita Baptist University, Riley Library (1963).
Batesville: Arkansas College Library (1963).
Clarksville: College of the Ozarks Library (1925).
Conway: Hendrix College, O. C. Bailey Library (1903).
Fayetteville: University of Arkansas Library (1907).
Little Rock:
- Arkansas Supreme Court Library (1962).
- Little Rock Public Library (1953).
- University of Arkansas at Little Rock Library (1973).

Magnolia: Southern Arkansas University, Mogale Library (1956).
Monticello: University of Arkansas at Monticello Library (1956).
Pine Bluff: University of Arkansas, Watson Memorial Library (1976).
Russellville: Arkansas Tech University, Tomlinson Library (1925).
Searcy: Harding College, Beaumont Memorial Library (1963).
State College: Arkansas State University, Dean B. Ellis Library (1913).
Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

Anaheim: Anaheim Public Library (1963).
Arcadia: Arcadia Public Library (1975).
Arcata: Humboldt State College Library (1963).
Bakersfield:
- California State College, Bakersfield Library (1974).
- Kern County Library System (1943).

Berkeley:
- University of California, General Library (1907).
- University of California, Law Library, Earl Warren Legal Center (1963).

Carson: Carson Regional Library (1973).
Chico: Chico State University Library (1962).
Claremont: Pomona College Documents Collection, Honnold Library (1913).
Compton: Compton Library (1972).
Culver City: Culver City Library (1966).
Davis:
- University of California at Davis Library (1953).

University of California at Davis, School of Law Library (1972).
Dominguez Hills: California State College, Dominguez Hills, Educational Resources Center (1973).
Downey: Downey City Library (1963).
Fresno:
Fresno County Free Library (1920).
California State University Library (1962).
Fullerton: California State University at Fullerton Library (1963).
Garden Grove: Garden Grove Regional Library (1963).
Gardena: Gardena Public Library (1966).
Hayward: California State College at Hayward Library (1963).
Huntington Park: Huntington Park Library, San Antonio Region (1970).
Inglewood: Inglewood Public Library (1963).
Irvine: University of California at Irvine Library (1963).
La Jolla: University of California, San Diego, University Library (1963).
Lakewood: Angelo Iacoboni Public Library (1970).
Lancaster: Lancaster Regional Library (1967).
Long Beach:
California State College at Long Beach Library (1962).
Long Beach Public Library (1933).
Los Angeles:
California State College at Los Angeles, John F. Kennedy Memorial Library (1956).
Los Angeles County Law Library (1963).
Los Angeles Public Library (1891).
Loyola University of Los Angeles Library (1933).
Occidental College, Mary Norton Clapp Library (1941).
Pepperdine University Library (1963).
Southwestern University, School of Law Library (1975).
University of California at Los Angeles Library (1932).
University of California at Los Angeles, Law Library (1958).
University of Southern California Library (1933).
Menlo Park: Department of the Interior, Geological Survey Library (1962).
Montebello: Montebello Library (1966).
Monterey: Naval Postgraduate School Library (1963).
Monterey Park: Bruggemeyer Memorial Library (1964).
Northridge: California State University at Northridge Library (1958).
Norwalk: Los Cerritos Regional Library (1973).
Oakland:
Mills College Library (1966).
Oakland Public Library (1923).
Ontario: Ontario City Library (1974).
Pasadena:
California Institute of Technology, Millikan Memorial Library (1933).
Pasadena Public Library (1963).
Pleasant Hill: Contra Costa County Library (1964).
Redding: Shasta County Library (1956).
Redlands: University of Redlands, Armacost Library (1933).
Redwood City: Redwood City Public Library (1966).
Reseda: West Valley Regional Branch Library (1966).
Richmond: Richmond Public Library (1943).
Riverside:
Riverside Public Library (1947).
University of California at Riverside Library (1963).
Sacramento:
California State Library (1895)—REGIONAL.
Sacramento City-County Library (1880).
Sacramento County Law Library (1963).
Sacramento State College Library (1963).
San Bernardino: San Bernardino County Free Library (1964).
San Diego:
San Diego State University, Love Library (1962).
San Diego County Law Library (1973).
San Diego County Library (1966).
San Diego Public Library (1895).
University of San Diego Law Library (1967).
San Francisco:
Mechanics' Institute Library (1889).
San Francisco Public Library (1889).
San Francisco State College, Social Science and Business Library (1955).
Supreme Court of California Library (1972).
U.S. Court of Appeals for Ninth Circuit Library (1971).
University of San Francisco, Richard A. Gleeson Library (1963).
San Jose: San Jose State College Library (1962).
San Leandro: San Leandro Community Library Center (1961).
San Luis Obispo: California Polytechnic State University Library (1969).
San Rafael: Marin County Free Library (1975).
Santa Ana:
Orange County Law Library (1975).
Santa Ana Public Library (1959).
Santa Barbara: University of California at Santa Barbara Library (1960).
Santa Clara: University of Santa Clara, Orradre Library (1963).
Santa Cruz: University of California at Santa Cruz Library (1963).
Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).
Stanford: Stanford University Libraries (1895).
Stockton: Public Library of Stockton and San Joaquin County (1884).
Thousand Oaks: California Lutheran College Library (1964).
Torrance: Torrance Civic Center Library (1969).
Turlock: Stanislaus State College Library (1964).
Valencia: Valencia Regional Library (1972).
Van Nuys: Los Angeles Valley College Library (1970).
Ventura: Ventura County Library Services Agency (1975).
Visalia: Tulare County Free Library (1967).
Walnut: Mount San Antonio College Library (1966).
West Covina: West Covina Library (1966).
Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

COLORADO

Alamosa: Adams State College Learning Resources Center (1963).
Boulder: University of Colorado Libraries (1879)—REGIONAL.
Colorado Springs:
Colorado College, Charles Leaming Tutt Library (1880).
University of Colorado, Colorado Springs Library (1974).
Denver:
Colorado State Library (unknown).
Denver Public Library (1884)—REGIONAL.
Department of Interior, Bureau of Reclamation Library (1962).
Regis College, Dayton Memorial Library (1915).
University of Denver, Penrose Library (1909).
U.S. Court of Appeals for Tenth Circuit Library (1973).
Fort Collins: Colorado State University Library (1907).
Golden: Colorado School of Mines, Arthur Lakes Library (1939).
Greeley: University of Northern Colorado Library (1966).
Gunnison: Western State College, Leslie J. Savage Library (1932).
La Junta: Otero Junior College, Wheeler Library (1963).
Lakewood: Jefferson County Public Library, Lakewood Regional Library (1968).

Pueblo:
Pueblo Regional Library (1893).
University Southern Colorado Library (1965).
U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).
Danbury: Western Connecticut State College, Ruth A. Haas Library (1967).
Danielson: Quinebaug Valley Community College (1975).
Enfield: Enfield Public Library (1967).
Hartford:
Connecticut State Library (unknown)—REGIONAL.
Hartford Public Library (1945).
Trinity College Library (1895).
Middletown: Wesleyan University Library (1906).
Mystic: Marine Historical Association, Inc., G. W. Blunt White Library (1964).
New Britain: Central Connecticut State College, Elihu Burritt Library (1973).
New Haven:
Southern Connecticut State College Library (1968).
Yale University Library (1859).
New London:
Connecticut College Library (1926).
U.S. Coast Guard Academy Library (1939).
Stamford: Stamford Public Library (1973).
Storrs: University of Connecticut, Wilbur Cross Library (1907).
Waterbury: Silas Bronson Library (1869).
West Haven: University of New Haven Library (1971).

DELAWARE

Dover:
Delaware State College, William C. Jason Library (1962).
State Department of Community Affairs and Economic Development, Division of Libraries (1972).
State Law Library in Kent County (unknown).
Georgetown:
Delaware Technical and Community College, Southern Branch Library (1968).
Sussex County Law Library (1976).
Newark:
University of Delaware, Morris Library (1907).
Delaware Law School Library (1976).
Wilmington:
New Castle County Law Library (1974).
Wilmington Institute and New Castle County Library (1861).

DISTRICT OF COLUMBIA

Washington:
Advisory Commission on Intergovernmental Relations Library.
Civil Aeronautics Board Library (1975).
Civil Service Commission Library (1963).
Department of Commerce Library (1955).
Department of Health, Education, and Welfare Library (1954).
Department of Housing and Urban Development Library (1969).
Department of the Interior Central Library (1895).
Department of Justice Main Library (1895).
Department of Labor Library (1976).
Department of State Library (1895).
Department of State, Office of Legal Advisor, Law Library (1966).
Department of Transportation, National Highway Traffic Safety Administration Library (1968).
District of Columbia Public Library (1943).
Federal City College Library (1970).
Federal Deposit Insurance Corporation Library (1972).
Federal Election Commission Library (1975).
Federal Reserve System Law Library (1976).
General Accounting Office Library (1975).
General Services Administration Library (1975).
Georgetown University Library (1969).
Indian Claims Commission Library (1968).
National War College Library (1895).
Navy Department Library (1895).
Navy Department, Office of Judge Advocate General Library (1963).
Office of Management and Budget Library (1965).
Office of The Adjutant General, Department of Army Library (1969).
Postal Service Library (1895).
Treasury Department Library (1895).
U.S. Court of Appeals, Judge's Library (1975).
Veterans' Administration, Central Office Library (1967).

FLORIDA

Boca Raton: Florida Atlantic University Library (1963).
Clearwater: Clearwater Public Library (1972).
Coral Gables: University of Miami Library (1939).
Daytona Beach: Volusia County Public Libraries (1963).
DeLand: Stetson University, duPont-Ball Library (1887).
Fort Lauderdale:
Broward County Library (1967).
Nova University Library (1967).
Gainesville: University of Florida Libraries (1907)—REGIONAL.
Jacksonville:
Haydon Burns Library (1914).
Jacksonville University, Swisher Library (1962).
University of North Florida Library (1972).
Lakeland: Lakeland Public Library (1928).
Leesburg: Lake-Sumter Community College Library (1963).
Melbourne: Florida Institute of Technology Library (1963).
Miami:
Florida International University Library (1970).
Miami Public Library (1952).
Opa Locka: Biscayne College Library (1966).
Orlando: Florida Technological University Library (1966).
Palatka: St. Johns River Junior College Library (1963).
Pensacola: University of West Florida, John C. Pace Library (1966).
Port Charlotte: Charlotte County Library System (1973).
St. Petersburg:
St. Petersburg Public Library (1965).
Stetson University College Law Library (1975).
Sarasota: Sarasota Public Library (1970).
Tallahassee:
Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
State Library of Florida (1929).
Florida State University, R. M. Stozier Library (1941).
Florida Supreme Court Library (1974).
Tampa:
Tampa Public Library (1965).
University of South Florida Library (1962).
University of Tampa, Merle Kelce Library (1953).
Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

Albany: Albany Public Library (1964).
Americus: Georgia Southwestern College, James Earl Carter Library (1966).
Athens: University of Georgia Libraries (1907).
Atlanta:
- Atlanta Public Library (1880).
- Atlanta University, Trevor Arnett Library (1962).
- Emory University, Robert W. Woodruff Library (1928).
- Emory University, School of Law Library (1968).
- Georgia Institute of Technology, Price Gilbert Memorial Library (1963).
- Georgia State Library (unknown).
- Georgia State University Library (1970).

Augusta: Augusta College Library (1962).
Brunswick: Brunswick Public Library (1965).
Carrollton: West Georgia College, Sanford Library (1962).
Columbus: Columbus College, Simon Schwob Memorial Library (1975).
Dahlonega: North Georgia College Library (1939).
Decatur: Dekalb Community College-South Campus, Learning Resources Center (1973).
Gainesville: Chestatee Regional Library (1968).
Macon: Mercer University Library (1964).
Marietta: Kennesaw Junior College Library (1968).
Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).
Mount Berry: Berry College, Memorial Library (1970).
Savannah: Savannah Public and Chatham-Effingham Liberty Regional Library (1857).
Statesboro: Georgia Southern College, Rosenwald Library (1939).
Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

GUAM

Agana: Nieves M. Flores Memorial Library (1962).

HAWAII

Hilo: University of Hawaii, Hilo Campus Library (1962).
Honolulu:
- Chaminade College of Honolulu Library (1965).
- Hawaii Medical Library, Inc. (1968).
- Hawaii State Library (1929).
- Municipal Reference Library of the City and County of Honolulu (1965).
- Supreme Court Law Library (1973).
- University of Hawaii Library (1907).

Laie: Church College of Hawaii, Woolley Library (1964).
Lihue: Kauai Public Library (1967).
Pearl City: Leeward Community College Library (1967).
Wailuku: Maui Public Library (1962).

IDAHO

Boise:
- Boise State College Library (1966).
- Boise Public Library and Information Center (1929).
- Idaho State Law Library (unknown).
- Idaho State Library (1971).

Caldwell: College of Idaho, Terteling Library (1930).
Moscow: University of Idaho Library (1907)—REGIONAL.
Pocatello: Idaho State University Library (1908).
Rexburg: Ricks College, David O. McKay Library (1946).
Twin Falls: College of Southern Idaho Library (1970).

ILLINOIS

Bloomington: Illinois Wesleyan University Libraries (1964).
Carbondale: Southern Illinois University Library (1932).
Carlinville: Blackburn College Library (1954).
Carterville: Shawnee Library System (1971).
Champaign: University of Illinois Law Library, College of Law (1965).
Charleston: Eastern Illinois University, Booth Library (1962).
Chicago:
- Chicago Public Library (1876).
- Chicago State University Library (1954).
- DePaul University, Lincoln Park Campus Library (1975).
- Field Museum of Natural History Library (1963).
- John Crerar Library (1909).
- Loyola University of Chicago, E. M. Cudahy Memorial Library (1966).
- Northeastern Illinois University Library (1961).
- University of Chicago Law Library (1964).
- University of Chicago Library (1897).
- University of Illinois, Chicago Circle Campus Library (1957).

Decatur: Decatur Public Library (1954).
De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).
Edwardsville: Southern Illinois University, Lovejoy Library (1959).
Elsah: Principia College, Marshall Brooks Library (1957).
Evanston: Northwestern University Library (1876).
Freeport: Freeport Public Library (1905).
Galesburg: Galesburg Public Library (1896).
Jacksonville: MacMurray College, Henry Pfeiffer Library (1929).
Kankakee: Olivet Nazarene College, Benner Library and Resource Center (1946).
Lake Forest: Lake Forest College, Donnelley Library (1962).
Lebanon: McKendree College, Holman Library (1968).
Lisle: Illinois Benedictine College, Theodore F. Lownik Library (1911).
Lockport: Lewis University Library (1952).
Macomb: Western Illinois University Memorial Library (1962).
Moline: Black Hawk College, Learning Resources Center (1970).
Monmouth: Monmouth College Library (1860).
Morton Grove: Oakton Community College Library (1976).
Mt. Carmel: Wabash Valley College Library (1975).
Normal: Illinois State University, Milner Library (1877).
Oak Park: Oak Park Public Library (1963).
Oglesby: Illinois Valley Community College Library (1976).
Palos Hills: Moraine Valley Community College Library (1972).
Park Forest South: Governors State University Library (1974).
Peoria:
- Bradley University, Cullom Davis Library (1963).
- Peoria Public Library (1883).

River Forest: Rosary College Library (1966).
Rockford: Rockford Public Library (unknown).
Springfield: Illinois State Library (unknown)—REGIONAL.
Urbana: University of Illinois Library (1907).
Wheaton: Wheaton College Library (1964).
Woodstock: Woodstock Public Library (1963).

INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).
Bloomington: Indiana University Library (1881).
Crawfordsville: Wabash College, Lilly Library (1906).
Evansville:
- Evansville and Vanderburgh County Public Library (1928).
- Indiana State University, Evansville Campus Library (1969).

Fort Wayne:
- Indiana-Purdue Universities, Regional Campus Library (1965).
- Public Library of Fort Wayne and Allen County (1896).

Franklin: Franklin College Library (1976).
Gary:
- Gary Public Library (1943).
- Indiana University, Northwest Campus Library (1966).

Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College Library (1892).
Huntington: Huntington College Library (1964).
Indianapolis:
- Butler University, Irwin Library (1965).
- Indiana State Library (unknown)—REGIONAL.
- Indiana Supreme Court Law Library (1975).
- Indiana University, Law Library (1967).
- Indianapolis-Marion County Public Library (1906).

Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
Lafayette: Purdue University Library (1907).
Muncie:
- Ball State University Library (1959).
- Muncie Public Library (1906).

New Albany: Indiana University, Southeastern Campus Library (1965).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
- Earlham College, Lilly Library (1964).
- Morrison-Reeves Library (1906).

South Bend: Indiana University at South Bend Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso: Valparaiso University, Moellering Memorial Library (1930).

IOWA

Ames: Iowa State University of Science and Technology Library (1907).
Cedar Falls: University of Northern Iowa Library (1946).
Council Bluffs:
- Free Public Library (1885).
- Iowa Western Community College, Hoover Media Library (1972).

Davenport: Davenport Public Library (1973).
Des Moines:
- Drake University, Cowles Library (1966).
- Drake University Law Library (1972).
- Iowa State Traveling Library (unknown).
- Public Library of Des Moines (1888).

Dubuque:
- Carnegie-Stout Public Library (unknown).
- Loras College, Wahlert Memorial Library (1967).

Fayette: Upper Iowa College, Henderson-Wilder Library (1974).
Grinnell: Grinnell College, Burling Library (1874).
Iowa City:
- University of Iowa, Law Library (1968).
- University of Iowa Library (1884)—REGIONAL.

Lamoni: Graceland College, Frederick Madison Smith Library (1927).
Mason City: North Iowa Area Community College Library (1976).
Mount Vernon: Cornell College, Russell D. Cole Library (1896).
Orange City: Northwestern College, Ramaker Library (1970).
Sioux City: Sioux City Public Library (1894).

KANSAS

Atchison: Benedictine College Library (1965).
Baldwin City: Baker University Library (1908).
Colby: Colby Community Junior College Library (1968).
Emporia: Kansas State College, William Allen White Library (1909).
Hays: Fort Hays Kansas State College, Forsyth Library (1926).
Hutchinson: Hutchinson Public Library (1963).
Lawrence:
- University of Kansas, Watson Library (1869)—REGIONAL.
- University of Kansas Law Library (1971).

Manhattan: Kansas State University, Farrell Library (1907).
Pittsburg: Kansas State College of Pittsburg, Porter Library (1952).
Salina: Kansas Wesleyan University, Memorial Library (1930).
Topeka:
- Kansas State Historical Society Library (1877).
- Kansas State Library (unknown).
- Kansas Supreme Court Law Library (1975).
- Washburn University of Topeka, Law Library (1971).

Wichita: Wichita State University Library (1901).

KENTUCKY

Ashland: Ashland Public Library (1946).
Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
Bowling Green: Western Kentucky University, Cravens Graduate Center and Library (1934).
Covington: Thomas More College Library (1970).
Danville: Centre College, Grace Doherty Library (1884).
Frankfort:
- Kentucky Department of Libraries (1967).
- Kentucky State University, Blazer Library (1972).
- State Law Library (unknown).

Highland Heights: Northern Kentucky State College Library (1973).
Hopkinsville: Hopkinsville Community College Library (1976).
Lexington:
- University of Kentucky, Law Library (1968).
- University of Kentucky, Margaret I. King Library (1907)—REGIONAL.

Louisville:
- Louisville Free Public Library (1904).
- University of Louisville, Belknap Campus Library (1925).
- University of Louisville Law Library (1975).

Morehead: Morehead State University, Johnson Camden Library (1955).
Murray: Murray State University Library (1924).
Owensboro: Kentucky Wesleyan College Library (1966).
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

LOUISIANA

Baton Rouge:
- Louisiana State Library (1976).
- Louisiana State University Law Library (1929).
- Louisiana State University Library (1907)—REGIONAL.
- Southern University Library (1952).

Eunice: Louisiana State University at Eunice, Le Doux Library (1969).

Hammond: Southeastern Louisiana University, Sims Memorial Library (1966).

Lafayette: University of Southwestern Louisiana Library (1938).

Lake Charles: McNeese State University, Frazar Memorial Library (1941).

Monroe: Northeast Louisiana University, Sandel Library (1963).

Natchitoches: Northwestern State University, Watson Memorial Library (1887).

New Orleans:
- Isaac Delgado College, Moss Technical Library (1968).
- Law Library of Louisiana (unknown).
- University of New Orleans Library (1963).
- Loyola University Library (1942).
- New Orleans Public Library (1883).
- Southern University in New Orleans Library (1962).
- Tulane University, Howard-Tilton Memorial Library (1942).
- Tulane University Law Library (1976).
- U.S. Court of Appeals, Fifth Circuit Library (1973).

Pineville: Louisiana College, Richard W Norton Memorial Library (1969).

Ruston: Louisiana Technical University Library (1896)—REGIONAL.

Shreveport:
- Louisiana State University at Shreveport Library (1967).
- Shreve Memorial Library (1923).

Thibodaux: Francis T. Nicholls State University, Leonidas Polk Library (1962).

MAINE

Augusta:
- Maine Law and Legislative Reference Library (1973).
- Maine State Library (unknown).

Bangor: Bangor Public Library (1884).

Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).

Castine: Maine Maritime Academy, Nutting Memorial Library (1969).

Lewiston: Bates College Library (1883).

Orono: University of Maine, Raymond H. Fogler Library (1907)—REGIONAL.

Portland:
- Portland Public Library (1884).
- University of Maine Law Library (1964).

Springvale: Nasson College Library (1961).

Waterville: Colby College Library (1884).

MARYLAND

Annapolis:
- Maryland State Library (unknown).
- U.S. Naval Academy, Nimitz Library (1895).

Baltimore:
- Enoch Pratt Free Library (1887).
- Johns Hopkins University, Milton S. Eisenhower Library (1882).
- Morgan State College, Soper Library (1940).
- University of Baltimore, Langsdale Library (1973).
- University of Maryland, Baltimore County Library (1971).
- University of Maryland, School of Law Library (1969).

Bel Air: Harford Community College Library (1967).

Beltsville: Department of Agriculture, National Agricultural Library (1895).

Chestertown: Washington College, Chester M. Miller Library (1891).

College Park: University of Maryland, McKeldin Library (1925)—REGIONAL.

Cumberland: Allegany Community College Library (1974).

Frostburg: Frostburg State College Library (1967).

Germantown: Energy Research & Development Adm. Library (1963).

Patuxent River: Naval Air Station Library (1968).

Rockville: Montgomery County Department of Public Libraries (1951).

Salisbury: Salisbury State College, Blackwell Library (1965).

Towson: Goucher College, Julia Rogers Library (1966).

Westminster: Western Maryland College Library (1896).

MASSACHUSETTS

Amherst:
- Amherst College Library (1884).
- University of Massachusetts, Goodell Library (1907).

Belmont: Belmont Memorial Library (1968).

Boston:
- Boston Athenaeum Library (unknown).
- Boston College, Bapst Library (1963).
- Boston Public Library (1859)—REGIONAL.
- Northeastern University, Dodge Library (1962).
- State Library of Massachusetts (unknown).

Brookline: Public Library of Brookline (1925).

Cambridge:
- Harvard College Library (1860).
- Massachusetts Institute of Technology Libraries (1946).

Chicopee: Our Lady of the Elms College Library (1969).

Lowell: Lowell Technological Institute, Alumni Memorial Library (1952).

Lynn: Lynn Public Library (1953).

Marlborough: Marlborough Public Library (1971).

Medford: Tufts University Library (1899).

Milton: Curry College Library (1972).

New Bedford: New Bedford Free Public Library (1858).

North Dartmouth: Southeastern Massachusetts University Library (1965).

North Easton: Stonehill College, Cushing-Martin Library (1962).

Springfield: Springfield City Library (1966).

Waltham: Brandeis University, Goldfarb Library (1965).

Wellesley: Wellesley College Library (1943).

Wenham: Gordon College, Winn Library (1963).

Williamstown: Williams College Library (unknown).

Worcester:
- American Antiquarian Society Library (1814).
- University of Massachusetts, Medical Center Library (1972).
- Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).

Allendale: Grand Valley State College Library (1963).

Alma: Alma College, Monteith Library (1963).

Ann Arbor:
Great Lakes Basin Commission Library (1971).
University of Michigan, Harlan Hatcher Library (1884).
Benton Harbor: Benton Harbor Public Library (1907).
Bloomfield Hills: Cranbrook Institute of Science Library (1940).
Dearborn:
Henry Ford Centennial Library (1969).
Henry Ford Community College Library (1957).
Detroit:
Detroit Public Library (1868)—REGIONAL.
Marygrove College Library (1965).
Mercy College of Detroit Library (1965).
University of Detroit Library (1884).
Wayne State University Law Library (1971).
Wayne State University, G. Flint Purdy Library (1937).
Dowagiac: Southwestern Michigan College Library (1971).
East Lansing:
Michigan State University, Law Library (1971).
Michigan State University Library (1907).
Escanaba: Michigan State Library, Upper Peninsula Branch (1964).
Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).
Flint:
Charles Stewart Mott Library (1959).
Flint Public Library (1967).
Grand Rapids:
Grand Rapids Public Library (1876).
Calvin College Library (1967).
Houghton: Michigan Technological University Library (1876).
Jackson: Jackson Public Library (1965).
Kalamazoo:
Kalamazoo Library System (1907).
Western Michigan University, Dwight B. Waldo Library (1963).
Lansing: Michigan State Library (unknown)—REGIONAL.
Livonia: Schoolcraft College Library (1962).
Marquette: Northern Michigan University, Olsen Library (1963).
Monroe: Monroe County Library System (1974).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Olivet: Olivet College Library (1974).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library System (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Library (1963).
Warren: Warren Public Library, Arthur J. Miller Branch (1973).
Wayne: Wayne Oakland Federated Library System (1957).
Ypsilanti: Eastern Michigan University Library (1965).

MINNESOTA

Bemidji: Bemidji State College, A. C. Clark Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Duluth: Duluth Public Library (1909).
Mankato: Mankato State College Memorial Library (1962).
Minneapolis:
Anoka County Library (1971).
Hennepin County Libraries (1971).
Minneapolis Public Library (1893).
University of Minnesota, Wilson Library (1907)—REGIONAL.
Moorhead: Moorhead State College Library (1956).
Morris: University of Minnesota at Morris Library (1963).
Northfield:
Carleton College Library (1930).
St. Olaf College, Rolvaag Memorial Library (1930).
St. Cloud: St. Cloud State College Library (1962).
St. Paul:
Minnesota Historical Society Library (1867).
Minnesota State Law Library (unknown).
St. Paul Public Library (1914).
University of Minnesota, St. Paul Campus Library (1974).
Saint Peter: Gustavus Adolphus College Library (1941).
Stillwater: Stillwater Public Library (1893).
Willmar: Crow River Regional Library (1958).
Winona: Winona State University, Maxwell Library (1969).

MISSISSIPPI

Cleveland: Delta State University, W. B. Roberts Library (1975).
Columbus: Mississippi State College for Women, J. C. Fant Memorial Library (1920).
Hattiesburg: University of Southern Mississippi Library (1935).
Jackson:
Jackson State College Library (1968).
Millsaps College, Millsaps-Wilson Library (1963).
Mississippi Library Commission (1947).
Mississippi State Law Library (unknown).
Lorman: Alcorn Agricultural and Mechanical College Library (1970).
State College: Mississippi State University, Mitchell Memorial Library (1907).
University:
University of Mississippi Library (1833)—REGIONAL.
University of Mississippi, School of Law Library (1967).

MISSOURI

Cape Girardeau: Southeast Missouri State College, Kent Library (1916).
Columbia: University of Missouri Library (1862).
Fayette: Central Methodist College Library (1962).
Fulton: Westminster College, Reeves Library (1875).
Jefferson City:
Lincoln University, Inman E. Page Library (1944).
Missouri State Library (1963).
Missouri Supreme Court Library (unknown).
Joplin: Missouri Southern State College Library (1966).
Kansas City:
Kansas City Public Library (1881).
Rockhurst College Library (1917).
University of Missouri at Kansas City, General Library (1938).
Kirksville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).
Liberty: William Jewell College Library (1900).
Rolla: University of Missouri at Rolla Library (1907).
St. Charles: Lindenwood College, Margaret Leggat Butler Library (1973).
St. Joseph: St. Joseph Public Library (1891).
St. Louis:
St. Louis County Library (1970).
St. Louis Public Library (1866).
St. Louis University, Law Library (1967).
St. Louis University, Pius XII Memorial Library (1866).

University of Missouri at St. Louis, Thomas Jefferson Library (1966).
U.S. Court of Appeals, Eighth Circuit Library (1972).
Washington University, John M. Olin Library (1906).
Springfield:
Drury College, Walker Library (1874).
Southwest Missouri State College Library (1963).
Warrensburg: Central Missouri State College, Ward Edwards Library (1914).

MONTANA

Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Helena:
Carroll College Library (1974).
Montana Historical Society Library (unknown).
Montana State Library (1966).
Missoula: University of Montana Library (1909)—REGIONAL.

NEBRASKA

Blair: Dana College, Dana-LIFE Library (1924).
Crete: Doane College, Whitin Library (1944).
Fremont: Midland Lutheran College Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).
Lincoln:
Nebraska Publications Clearinghouse, Nebraska Library Commission (1972)—REGIONAL.
Nebraska State Library (unknown).
University of Nebraska, Don L. Love Memorial Library (1907).
Omaha:
Creighton University, Alumni Library (1964).
Omaha Public Library (1880).
University of Nebraska at Omaha, University Library (1939).
Scottsbluff: Scottsbluff Public Library (1925).
Wayne: Wayne State College, U.S. Conn Library (1970).

NEVADA

Carson City:
Nevada State Library (unknown).
Nevada Supreme Court Library (1973).
Las Vegas:
Clark County Library District Library (1974).
University of Nevada at Las Vegas, James R. Dickinson Library (1959).
Reno:
Nevada State Historical Society Library (1974).
University of Nevada Library (1907)—REGIONAL.

NEW HAMPSHIRE

Concord:
Franklin Pierce Law Center Library (1973).
New Hampshire State Library (unknown).
Durham: University of New Hampshire Library (1907).
Franconia: Franconia College Library (1972).
Hanover: Dartmouth College, Baker Library (1884).
Henniker: New England College Library (1966).
Manchester:
Manchester City Library (1884).
New Hampshire College, H.A.B. Shapiro Memorial Library (1976).
St. Anselm's College, Geise Library (1963).
Nashua: Nashua Public Library (1971).

NEW JERSEY

Bayonne: Bayonne Free Public Library (1909).
Bloomfield: Free Public Library of Bloomfield (1965).
Bridgeton: Cumberland County Library (1966).
Camden: Rutgers University-Camden Library (1966).
Convent Station: College of St. Elizabeth, Mahoney Library (1938).
Dover: County College of Morris Library, Learning Resources Center (1975).
East Orange: East Orange Public Library (1966).
Elizabeth: Free Public Library of Elizabeth (1895).
Glassboro: Glassboro State College, Savitz Learning Resource Center (1963).
Hackensack: Johnson Free Public Library (1966).
Irvington: Free Public Library of Irvington (1966).
Jersey City:
Free Public Library of Jersey City (1879).
Jersey City State College, Forrest A. Irwin Library (1963).
Lawrenceville: Rider College Library (1975).
Madison: Drew University, Rose Memorial Library (1939).
Mahwah: Ramapo College Library (1971).
Mount Holly: Burlington County Library (1966).
New Brunswick:
Free Public Library (1908).
Rutgers University Library (1907).
Newark:
Newark Public Library (1906)—REGIONAL.
Rutgers-The State University, John Cotton Dana Library (1966).
Passaic: Passaic Public Library (1964).
Phillipsburg: Phillipsburg Free Public Library (1976).
Plainfield: Plainfield Public Library (1971).
Pomona: Stockton State College Library (1972).
Princeton: Princeton University Library (1884).
Rutherford: Fairleigh Dickinson University, Messler Library (1953).
Shrewsbury: Monmouth County Library (1968).
South Orange: Seton Hall University, McLaughlin Library (1947).
Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).
Toms River: Ocean County College Learning Resources Center (1966).
Trenton:
New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).
Trenton Free Public Library (1902).
Union: Kean College of New Jersey, Nancy Thompson Library (1973).
Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).
Wayne: Wayne Public Library (1972).
West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).
Woodbridge: Free Public Library of Woodbridge (1965).

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NEW MEXICO

Albuquerque:
- University of New Mexico, Medical Sciences Library (1973).
- University of New Mexico, School of Law Library (1973).
- University of New Mexico, Zimmerman Library (1896)—REGIONAL.

Hobbs: New Mexico Junior College, Pannell Library (1969).
Las Cruces: New Mexico State University Library (1907).
Las Vegas: New Mexico Highlands University, Donnelly Library (1913).
Portales: Eastern New Mexico University Library (1962).
Santa Fe:
- New Mexico State Library (1960)—REGIONAL.
- Supreme Court Law Library (unknown).

Silver City: Western New Mexico University, Miller Library (1972).

NEW YORK

Albany:
- New York State Library (unknown)—REGIONAL.
- State University of New York at Albany Library (1964).

Auburn: Seymour Library (1972).
Bayside: Queensborough Community College Library (1972).
Binghamton: State University of New York at Binghamton Library (1962).
Brockport: State University of New York, Drake Memorial Library (1967).
Bronx:
- Herbert H. Lehman College Library (1967).
- New York Public Library, Mott Haven Branch (1973).

Bronxville: Sarah Lawrence College Library (1969).
Brooklyn:
- Brooklyn College Library (1936).
- Brooklyn Law School, Law Library (1974).
- Brooklyn Public Library (1908).
- Polytechnic Institute of Brooklyn, Spicer Library (1963).
- Pratt Institute Library (1891).
- State University of New York, Downstate Medical Center Library (1958).

Buffalo:
- Buffalo and Erie County Public Library (1895).
- State University of New York at Buffalo, Lockwood Memorial Library (1963).

Canton: St. Lawrence University, Owen D. Young Library (1920).
Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).
Cortland: State University of New York, College at Cortland, Memorial Library (1964).
Delhi: State University Agricultural and Technical College Library (1970).
Douglaston: Cathedral College Library (1971).
East Islip: East Islip Public Library (1974).
Elmira: Elmira College, Gannett-Tripp Learning Center (1956).
Farmingdale: State University Agricultural and Technical Institute at Farmingdale Library (1917).
Flushing: Queens College, Paul Klapper Library (1939).
Garden City:
- Adelphi University, Swirbul Library (1966).
- Nassau Library System (1965).

Geneseo: State University College, Milne Library (1967).
Greenvale: C. W. Post College, B. Davis Schwartz Memorial Library (1965).
Hamilton: Colgate University Library (1902).
Hempstead: Hofstra University Library (1964).
Ithaca:
- Cornell University Library (1907).
- New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).

Jamaica:
- Queens Borough Public Library (1926).
- St. John's University Library (1956).

Kings Point: U.S. Merchant Marine Academy Library (1962).
Mount Vernon: Mount Vernon Public Library (1962).
New Paltz: State University College Library (1965).
New York City:
- City University of New York, City College Library (1884).
- College of Insurance, Ecker Library (1965).
- Columbia University Libraries (1882).
- Cooper Union Library (1930).
- Fordham University Library (1937).
- Medical Library Center of New York (1976).
- New York Law Institute Library (1909).
- New York Public Library (Astor Branch) (1907).
- New York Public Library (Lenox Branch) (1884).
- New York University Libraries (1967).
- New York University, Law Library (1973).
- State University of New York, Maritime College Library (1947).

Newburgh: Newburgh Free Library (1909).
Niagara Falls: Niagara Falls Public Library (1976).
Oakdale: Dowling College Library (1965).
Oneonta: State University College, James M. Milne Library (1966).
Oswego: State University College, Penfield Library (1966).
Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).
Potsdam:
- Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).
- State University College, Frederick W. Crumb Memorial Library (1964).

Poughkeepsie: Vassar College Library (1943).
Purchase: State University of New York, College at Purchase Library (1969).
Rochester:
- Rochester Public Library (1963).
- University of Rochester Library (1880).

St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).
Saratoga Springs: Skidmore College Library (1964).
Schenectady: Union College, Schaffer Library (1901).
Southampton: Southampton College Library (1973).
Staten Island (Grymes Hill): Wagner College, Horrmann Library (1953).
Stony Brook: State University of New York at Stony Brook Library (1963).
Syracuse: Syracuse University Library (1878).
Troy: Troy Public Library (1869).
Utica: Utica Public Library (1885).
West Point: U.S. Military Academy Library (unknown).
Yonkers:
- Yonkers Public Library (1910).

Yorktown Heights: Mercy College at Fox Meadow Library.

NORTH CAROLINA

Asheville: University of North Carolina at Asheville, D. Hiden Ramsey Library (1965).
Boiling Springs: Gardner-Webb College, Dover Memorial Library (1974).

Boone: Appalachian State University Library (1963).
Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).
Chapel Hill: University of North Carolina Library (1884)—REGIONAL.
Charlotte:
Public Library of Charlotte and Mecklenburg County (1964).
Queens College, Everette Library (1927).
University of North Carolina at Charlotte, Atkins Library (1964).
Cullowhee: Western Carolina University, Hunter Library (1953).
Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).
Durham:
Duke University, William R. Perkins Library (1890).
North Carolina Central University, James E. Shepard Memorial Library (1973).
Elon College: Elon College Library (1971).
Fayetteville: Fayetteville State University, Chesnutt Library (1971).
Greensboro:
North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).
University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).
Greenville: East Carolina University, J. Y. Joyner Library (1951).
Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).
Lexington: Davidson County Public Library System (1971).
Mount Olive: Mount Olive College, Moye Library (1971).
Murfreesboro: Chowan College, Whitaker Library (1963).
Pembroke: Pembroke State University Library (1965).
Raleigh:
North Carolina State Library (unknown).
North Carolina State University, D. H. Hill Library (1923).
North Carolina Supreme Court Library (1972).
Wake County Public Libraries (1969).
Rocky Mount: North Carolina Wesleyan College Library (1969).
Salisbury: Catawba College Library (1925).
Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).
Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).
Winston-Salem:
Forsyth County Public Library System (1954).
Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

Bismarck:
State Historical Society of North Dakota (1907).
North Dakota State Law Library (unknown).
State Library Commission Library (1971).
Veterans Memorial Public Library (1967).
Dickinson: Dickinson State College Library (1968).
Fargo:
Fargo Public Library (1964).
North Dakota State University Library (1907)—REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.
Grand Forks: University of North Dakota, Chester Fritz Library (1890).
Minot: Minot State College, Memorial Library (1925).
Valley City: State College Library (1913).

OHIO

Ada: Ohio Northern University, J. P. Taggart Law Library (1965).
Akron:
Akron Public Library (1952).
University of Akron Library (1963).
Alliance: Mount Union College Library (1888).
Ashland: Ashland College Library (1938).
Athens: Ohio University Library (1886).
Batavia: Clermont General and Technical College Library (1973).
Bluffton: Bluffton College, Musselman Library (1951).
Bowling Green: Bowling Green State University Library (1933).
Canton: Malone College, Everett L. Cattell Library (1970).
Chardon: Geauga County Public Library (1971).
Cincinnati:
Public Library of Cincinnati and Hamilton County (1884).
University of Cincinnati Library (1929).
Cleveland:
Case Western Reserve University, Freiberger Library (1913).
Cleveland Heights-University Heights Public Library (1970).
Cleveland Public Library (1886).
Cleveland State University Library (1966).
John Carroll University, Grasselli Library (1963).
Municipal Reference Library (1970).
Columbus:
Capital University Library (1968).
Columbus Public Library (1885).
Ohio State Library (unknown)—REGIONAL.
Ohio State University Library (1907).
Ohio Supreme Court Law Library (1973).
Dayton:
Dayton and Montgomery County Public Library (1909).
University of Dayton, Albert Emanuel Library (1969).
Wright State University Library (1965).
Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).
Elyria: Elyria Public Library (1966).
Findlay: Findlay College, Shafer Library (1969).
Gambier: Kenyon College Library (1873).
Granville: Denison University Library (1884).
Hiram: Hiram College, Teachout-Price Memorial Library (1874).
Kent: Kent State University Library (1962).
Marietta: Marietta College, Dawes Memorial Library (1884).
Middletown: Miami University at Middletown, Gardner-Harvey Library (1970).
New Concord: Muskingum College Library (1966).
Oberlin: Oberlin College Library (1858).
Oxford: Miami University, Alumni Library (1909).
Portsmouth: Portsmouth Public Library (unknown).
Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).
Springfield: Warder Public Library (1884).
Steubenville:
College of Steubenville, Starvaggi Memorial Library (1971).
Public Library of Steubenville and Jefferson County (1950).
Tiffin: Heidelberg College, Beeghly Library (1964).
Toledo:
Toledo-Lucas County Public Library (1884).
University of Toledo Library (1963).

Westerville: Otterbein College, Centennial Library (1967).
Wooster: College of Wooster, the Andrews Library (1966).
Youngstown:
Public Library of Youngstown and Mahoning County (1923).
Youngstown State University Library (1971).

OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).
Alva: Northwestern State College Library (1907).
Bartlesville: United States ERDA-BERC Library (1962).
Bethany: Bethany Nazarene College, R. T. Williams Library (1971).
Durant: Southeastern State College Library (1929).
Edmond: Central State University Library (1934).
Enid: Public Library of Enid and Garfield County (1908).
Langston: Langston University, G. Lamar Harrison Library (1941).
Muskogee: Muskogee Public Library (1971).
Norman: University of Oklahoma Libraries (1893).
Oklahoma City:
Oklahoma County Libraries (1974).
Oklahoma City University Library (1963).
Oklahoma Department of Libraries (1893)—REGIONAL.
Shawnee: Oklahoma Baptist University Library (1933).
Stillwater: Oklahoma State University Library (1907).
Tahlequah: Northeastern State College, John Vaughan Library (1923).
Tulsa:
Tulsa City-County Library (1963).
University of Tulsa, McFarlin Library (1929).
Weatherford: Southwestern Oklahoma State University, Al Harris Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).
Corvallis: Oregon State University Library (1907).
Eugene: University of Oregon Library (1883).
Forest Grove: Pacific University Library (1897).
La Grande: Eastern Oregon College, Walter M. Pierce Library (1954).
McMinnville: Linfield College, Northup Library (1965).
Monmouth: Oregon College of Education Library (1967).
Portland:
Department of the Interior, Bonneville Power Administration Library (1962).
Lewis and Clark College, Aubrey R. Watzek Library (1967).
Library Association of Portland (1884).
Portland State University Library (1963)—REGIONAL.
Reed College Library (1912).
Salem:
Oregon State Library (unknown).
Oregon Supreme Court Library (1974).
Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College, Haas Library (1939).
Altoona: Altoona Public Library (1969).
Bethlehem: Lehigh University, Linderman Library (1876).
Blue Bell: Montgomery County Community College, Learning Resources Center Library (1975).
Carlisle: Dickinson College, Boyd Lee Spahr Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College, Myrin Library (1963).
Doylestown: Bucks County Free Library, Center County Library (1970).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie Public Library (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: State Library of Pennsylvania (unknown)—REGIONAL.
Haverford: Haverford College Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria Public Library (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Reis Library (1907).
Millersville: Millersville State College, Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Free Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
Drexel University Library (1963).
Free Library of Philadelphia (1897).
St. Joseph's College Library (1974).
Temple University, Samuel Paley Library (1947).
U.S. Court of Appeals, Third Circuit (1973).
University of Pennsylvania, Biddle Law Library (1974).
University of Pennsylvania Library (1886).
Pittsburgh:
Bureau of Mines, Pittsburgh Research Center Library (1962).
Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
Carnegie Library of Pittsburgh (1895).
La Roche College, John J. Wright Library (1974).
University of Pittsburgh, Hillman Library (1910).
Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Shippensburg: Shippensburg State College, Ezra Lehman Memorial Library (1973).
Slippery Rock: Slippery Rock State College, Maltby Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Library (1907).
Villanova: Villanova University, School of Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, Memorial Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College, Corgan Library (1949).
Williamsport: Lycoming College Library (1970).
York: York Junior College Library (1963).
Youngwood: Westmoreland County Community College, Learning Resource Center (1972).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce: Catholic University of Puerto Rico Library (1966).
Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: Naval War College Library (1963).
Providence:
- Brown University, John D. Rockefeller, Jr. Library (unknown).
- Providence College, Phillips Memorial Library (1969).
- Providence Public Library (1884).
- Rhode Island College Library (1965).
- Rhode Island State Library (before 1895).

Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).

SOUTH CAROLINA

Charleston:
- Baptist College at Charleston Library (1967).
- College of Charleston Library (1869).
- The Citadel Memorial Library (1962).

Clemson: Clemson University Library (1893).
Columbia:
- Benedict College, Learning Resources Center (1969).
- South Carolina State Library (before 1895).
- University of South Carolina Undergraduate Library (1884).

Conway: University of South Carolina, Coastal Carolina Regional Campus Library (1974).
Due West: Erskine College, McCain Library (1968).
Florence:
- Florence County Library (1967).
- Francis Marion College, James A. Rogers Library (1970).

Greenville:
- Furman University Library (1962).
- Greenville County Library (1966).

Greenwood: Lander College Library (1967).
Orangeburg: South Carolina State College, Whittaker Library (1953).
Rock Hill: Winthrop College Library (1896).
Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

Aberdeen: Northern State College Library (1963).
Brookings: South Dakota State University, Lincoln Memorial Library (1889).
Pierre: South Dakota State Library (1973).
Rapid City:
- Rapid City Public Library (1963).
- South Dakota School of Mines and Technology Library (1963).

Sioux Falls:
- Augustana College, Mikkelsen Library and Learning Resources Center (1969).
- Sioux Falls Public Library (1903).

Spearfish: Black Hills State College Library (1942).
Vermillion: University of South Dakota, I. D. Weeks Library (1889).
Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

Bristol: King College Library (1970).
Chattanooga:
- Chattanooga-Hamilton County Bicentennial Library (1907).
- TVA Technical Library (1976).

Clarksville: Austin Peay State University, Felix G. Woodward Library (1945).
Cleveland: Cleveland State Community College Library (1973).
Columbia: Columbia State Community College Library (1973).
Cookeville: Tennessee Technological University, Jere Whitson Memorial Library (1969).
Jackson: Lambuth College, Luther L. Gobbel Library (1967).
Jefferson City: Carson-Newman College Library (1964).
Johnson City: East Tennessee State University, Sherrod Library (1942).
Knoxville:
- Public Library of Knoxville and Knox County, Lawson McGhee Library (1973).
- University of Tennessee Law Library (1971).
- University of Tennessee Library (1907).

Martin: University of Tennessee at Martin Library (1957).
Memphis:
- Memphis and Shelby County Public Library and Information Center (1896).
- Memphis State University, John W. Brister Library (1966).

Murfreesboro: Middle Tennessee State University, Andrew L. Todd Library (1912).
Nashville:
- Fisk University Library (1965).
- Joint University Libraries (1884).
- Public Library of Nashville and Davidson County (1884).
- Tennessee State Law Library (1976).
- Tennessee State Library and Archives, State Library Division (unknown).
- Tennessee State University, Martha M. Brown Memorial Library (1972).

Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

Abilene: Hardin-Simmons University Library (1940).
Arlington:
- Arlington Public Library (1970).
- University of Texas at Arlington Library (1963).

Austin:
- Texas State Law Library (1972).
- Texas State Library (unknown)—REGIONAL.
- University of Texas at Austin Library (1884).
- University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
- University of Texas, School of Law Library (1965).

Baytown: Lee College Library (1970).
Beaumont: Lamar University Library (1957).
Brownwood: Howard Payne College, Walker Memorial Library (1964).
Canyon: West Texas State University Library (1928).
College Station: Texas Agricultural and Mechanical University Library (1907).
Commerce: East Texas State University Library (1937).
Corpus Christi: Texas A&I University at Corpus Christi Library (1976).
Corsicana: Navarro Junior College Library (1965).
Dallas:
- Bishop College, Zale Library (1966).
- Dallas Baptist College Library (1967).

Dallas Public Library (1900).
Southern Methodist University, Fondren Library (1925).
University of Texas Health Science Center Library at Dallas (1975).
Denton: North Texas State University Library (1948).
Edinburg: Pan American University Library (1959).
El Paso:
El Paso Public Library (1906).
University of Texas at El Paso Library (1966).
Fort Worth:
Fort Worth Public Library (1905).
Texas Christian University, Mary Couts Burnett Library (1916).
Galveston: Rosenberg Library (1909).
Houston:
Houston Public Library (1884).
North Harris County College, Learning Resource Center (1974).
Rice University, Fondren Library (1967).
University of Houston Library (1957).
Huntsville: Sam Houston State University, Estill Library (1949).
Irving: Irving Municipal Library (1974).
Kingsville: Texas Arts and Industries University Library (1944).
Lake Jackson: Brazosport College Library (1969).
Laredo: Laredo Junior College Library (1970).
Longview: Nicholson Memorial Public Library (1961).
Lubbock: Texas Tech University Library (1935)—REGIONAL.
Marshall: Wiley College, Cole Library (1962).
Mesquite: Mesquite Public Library (1975).
Nacogdoches: Stephen F. Austin State University Library (1965).
Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
Richardson: University of Texas at Dallas Library (1972).
San Angelo: Angelo State University, Porter Henderson Library (1964).
San Antonio:
San Antonio College Library (1972).
San Antonio Public Library, Business and Science Department (1899).
St. Mary's University Library (1964).
Trinity University Library (1964).
University of Texas at San Antonio Library (1973).
San Marcos: Southwest Texas State University Library (1955).
Seguin: Texas Lutheran College, Blumberg Memorial Library (1970).
Sherman: Austin College, Arthur Hopkins Library (1963).
Texarkana: Texarkana Community College, Palmer Memorial Library (1963).
Victoria: University of Houston, Victoria Center Library (1973).
Waco: Baylor University Library (1905).
Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

Cedar City: Southern Utah State College Library (1964).
Ephraim: Snow College, Lucy A. Phillips Library (1963).
Logan: Utah State University, Merrill Library and Learning Resources Center (1907)—REGIONAL.
Ogden: Weber State College Library (1962).
Provo:
Brigham Young University, Lee Library (1908).
Brigham Young University Law Library (1972).
Salt Lake City:
Utah State Supreme Court Law Library (1975).
University of Utah, Eccles Medical Sciences Library (1970).
University of Utah, Law Library (1966).
University of Utah, Marriott Library (1893).
Utah State Library Commission, Documents Library (unknown).

VERMONT

Burlington: University of Vermont, Bailey Library (1907).
Castleton: Castleton State College, Calvin Coolidge Library (1969).
Johnson: Johnson State College, John Dewey Library (1955).
Lyndonville: Lyndon State College, Samuel Reed Hall Library (1969).
Middlebury: Middlebury College, Egbert Starr Library (1884).
Montpelier: Vermont Department of Libraries (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas): College of the Virgin Islands, Ralph M. Paiewonsky Library (1973).
St. Thomas Public Library (1968).
Christiansted (St. Croix): Christiansted Public Library (1974).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
University of Virginia, Alderman Library (1910)—REGIONAL.
University of Virginia Law Library (1964).
Chesapeake: Chesapeake Public Library System (1970).
Danville: Danville Community College Library (1969).
Emory: Emory and Henry College Library (1884).
Fairfax: George Mason College of the University of Virginia, Fenwick Library (1960).
Fredericksburg: Mary Washington College, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Harrisonburg: Madison College, Madison Memorial Library (1973).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
Virginia Military Institute, Preston Library (1874).
Washington and Lee University, Cyrus Hall McCormick Library (1910).
Martinsville: Patrick Henry Community College Library (1971).
Norfolk:
Armed Forces Staff College Library (1963).
Norfolk Public Library (1895).
Old Dominion University Library (1963).
Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico:
Federal Bureau of Investigation Academy Library (1970).
Marine Corps Schools, James Carson Breckinridge Library (1967).

Reston: Department of the Interior, Geological Survey Library (1962).
Richmond:
State Law Library (1973).
University of Richmond, Boatwright Memorial Library (1900).
U.S. Court of Appeals, Fourth Circuit Library (1973).
Virginia Commonwealth University, James Branch Cabell Library (1971).
Virginia State Library (unknown).
Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College Library (1936).
Wise: Clinch Valley College, John Cook Wyllie Library (1971).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington State College Library (1962).
Everett: Everett Public Library (1914).
Olympia:
Evergreen State College Library (1972).
Washington State Library (unknown)—REGIONAL.
Port Angeles: North Olympic Library System (1965).
Pullman: Washington State University Library (1907).
Seattle:
Seattle Public Library (1908).
University of Washington Library (1890).
University of Washington, School of Law Library (1969).
Spokane: Spokane Public Library (1910).
Tacoma:
Tacoma Public Library (1894).
University of Puget Sound, Collins Memorial Library (1938).
Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Bluefield: Bluefield State College Library (1972).
Charleston:
Kanawha County Public Library (1952).
West Virginia Library Commission (unknown).
Elkins: Davis and Elkins College Library (1913).
Fairmont: Fairmont State College Library (1884).
Glenville: Glenville State College, Robert F. Kidd Library (1966).
Huntington: Marshall University Library (1925).
Institute: West Virginia State College Library (1907).
Morgantown: West Virginia University Library (1907)—REGIONAL.
Salem: Salem College Library (1921).
Shepherdstown: Shepherd College Library (1971).
Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Seeley G. Mudd Library (1869).
Beloit: Beloit College Libraries (1888).
Eau Claire: University of Wisconsin, Eau Claire, William D. McIntyre Library (1951).
Fond du Lac: Fond du Lac Public Library (1966).
Green Bay: University of Wisconsin at Green Bay Library (1968).
La Crosse:
La Crosse Public Library (1883).
University of Wisconsin-La Crosse, Murphy Library (1965).
Madison:
Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).
Madison Public Library (1965).
State Historical Society Library (1870)—REGIONAL, in cooperation with University of Wisconsin, Memorial Library.
University of Wisconsin, Memorial Library (1939).
Wisconsin State Library (unknown).
Milwaukee:
Alverno College Library (1971).
Milwaukee County Law Library (1934).
Milwaukee Public Library (1861)—REGIONAL.
Mount Mary College Library (1964).
University of Wisconsin-Milwaukee Library (1960).
Oshkosh: University of Wisconsin-Oshkosh, Forrest R. Polk Library (1956).
Platteville: University of Wisconsin-Platteville, Elton S. Karrmann Library (1964).
Racine: Racine Public Library (1898).
River Falls: University of Wisconsin-River Falls, Chalmer Davee Library (1962).
Stevens Point: University of Wisconsin-Stevens Point, Learning Resources Center (1951).
Superior:
Superior Public Library (1908).
University of Wisconsin-Superior, Jim Dan Hill Library (1935).
Waukesha: Waukesha Public Library (1966).
Wausau: Marathon County Public Library (1971).
Whitewater: University of Wisconsin-Whitewater, Harold Andersen Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).
Cheyenne: Wyoming State Library (unknown)—REGIONAL.
Laramie: University of Wyoming, Coe Library (1907).
Powell: Northwest Community College Library (1967).
Riverton: Central Wyoming College Library (1969).
Rock Springs: Western Wyoming College Library (1969).
Sheridan: Sheridan College, Mary Brown Kooi Library (1963).

APPENDIX B. LIST OF FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

ALABAMA

Birmingham—Gayle C. Shelton, Jr., Director, Suite 200-201, 908 South 20th Street 35205, Area Code 205 Tel 254-1331, FTS 229-1331

ALASKA

****Anchorage**—Sara L. Haslett, Director, 412 Hill Building, 632 Sixth Avenue 99501, Area Code 907 Tel 265-5307

ARIZONA

****Phoenix—Donald W. Fry, Director, Suite 2950 Valley Center Bank Bldg., 201 North Central Avenue 85004. Area Code 602 Tel 261-3285, FTS 261-3285**

ARKANSAS

***Little Rock (Dallas, Texas District)**—1100 North University, Suite 109 72207, Area Code 501 Tel 378-5157, FTS 740-5157

CALIFORNIA

Los Angeles—Eric C. Silberstein, Director, Room 800, 11777 San Vicente Boulevard 90049, Area Code 213 Tel 824-7591, FTS 799-7591

***San Diego**—233 A Street, Suite 310 92101, Area Code 714 Tel 293-5395, FTS 895-5395

San Francisco—Philip M. Creighton, Director, Federal Building, Box 36013, 450 Golden Gate Avenue 94102, Area Code 415 Tel 556-5860, FTS 556-5868

COLORADO

Denver—Norman Lawson, Director, Room 165, New Customhouse, 19th & Stout Street 80202, Area Code 303 Tel 837-3246, FTS 327-3246

CONNECTICUT

Hartford—Richard C. Kilbourn, Director, Room 610-B, Federal Office Building, 450 Main Street 06103, Area Code 203 Tel 244-3530, FTS 244-3530

FLORIDA

Miami—Roger J. LaRoche, Director, Room 821, City National Bank Building, 25 West Flagler Street 33130, Area Code 305 Tel 350-5267, FTS 350-5267

***Clearwater**—128 North Osceola Avenue 33515, Area Code 813 Tel 446-4081

***Jacksonville**—604 North Hogan Street 32202, Area Code 904 Tel 791-2796, FTS 946-2796

***Tallahassee**—Collins Building, Rm. G-20 32304, Area Code 904 Tel 488-6469, FTS 946-4320

GEORGIA

Atlanta—David S. Williamson, Director, Suite 600, 1365 Peachtree Street, N.E. 30309, Area Code 404 Tel 526-6000, FTS 285-6000

Savannah—James W. McIntire, Director, 235 U.S. Courthouse & P.O. Building, 125-29 Bull Street 31402, Area Code 912 Tel 232-4321, Ext. 204, FTS 287-4204

HAWAII

Honolulu—John S. Davies, Director, 286 Alexander Young Building, 1015 Bishop Street 96813, Area Code 808 Tel 546-8694

IDAHO

***Boise (Portland, Oregon District)**—P.O. Box 9366, 83707, Area Code 208 Tel 342-2711, FTS 588-2326

ILLINOIS

Chicago—Gerald M. Marks, Director, 1406 Mid Continental Plaza Building, 55 East Monroe Street 60603, Area Code 312 Tel 353-4450, FTS 353-6957

INDIANA

Indianapolis—Mel R. Sherar, Director, 357 U.S. Courthouse & Federal Office Building, 46 East Ohio Street 46204, Area Code 317 Tel 269-6214, FTS 331-6214

IOWA

Des Moines—Jesse N. Durden, Director, 609 Federal Building, 210 Walnut Street 50309, Area Code 515 Tel 284-4222, FTS 862-4222

KANSAS

***Wichita (St. Louis, Missouri District)**—Wichita State University, Clinton Hall, Room 341, 67208, Area Code 316 Tel 267-6160, FTS 752-6160

KENTUCKY

***Frankfort (Memphis, Tennessee District)**—Capitol Plaza Office Tower, Room 2332, 40601, Area Code 502 Tel 875-4421

LOUISIANA

New Orleans—Edwin A. Leland, Jr., Director, 432 International Trade Mart, No. 2 Canal Street 70130, Area Code 504 Tel 589-6546, FTS 682-6546

MAINE

***Portland (Boston, Massachusetts District)**—Maine State Pier, 40 Commercial Street 04111, Area Code 207 Tel 775-3131, FTS 833-3236

MARYLAND

Baltimore—Carroll F. Hopkins, Director, 415 U.S. Customhouse, Gay and Lombard Streets 21202, Area Code 301 Tel 962-3560, FTS 922-3560

MASSACHUSETTS

Boston—Richard F. Treadway, Director, 10th Floor, 441 Stuart Street 02116, Area Code 617 Tel 223-2312, FTS 223-2312

MICHIGAN

Detroit—William L. Welch, Director, 445 Federal Building, 231 West Lafayette 48226, Area Code 313 Tel 226-3650, FTS 226-3650

***Ann Arbor**—Graduate School of Business Administration, University of Michigan Room 288, 48105, Area Code 313 Tel 994-3297, FTS 374-5638

***Grand Rapids**—17 Fountain Street N.W. 49503, Area Code 616 Tel 456-2411/33, FTS 372-2411

MINNESOTA

Minneapolis—Glenn A. Matson, Director, 218 Federal Building, 110 South Fourth Street 55401, Area Code 612 Tel 725-2133, FTS 725-2133

MISSISSIPPI

***Jackson (Birmingham, Alabama District)**—P.O. Box 849, 2003 Walter Sillers Building 39205, Area Code 601 Tel 969-4388, FTS 490-4388

MISSOURI

St. Louis—Donald R. Loso, Director, 120 South Central Avenue 63105, Area Code 314 Tel 425-3302-4, FTS 279-3302

***Kansas City**—Room 1840, 601 East 12th Street 64106, Area Code 816 Tel 374-3142, FTS 758-3142

MONTANA

***Butte (Cheyenne, Wyoming District)**—210 Miners Bank Building, Park Street 59701, Area Code 406 Tel 723-6561, Ext. 2317, FTS 585-2317

NEBRASKA

Omaha—George H. Payne, Director, Capitol Plaza, Suite 703A, 1815 Capitol Avenue 68102, Area Code 402 Tel 221-3665, FTS 864-3665

NEVADA

Reno—Joseph J. Jeremy, Director, 2028 Federal Building, 300 Booth Street 89502, Area Code 702 Tel 784-5203, FTS 598-5203

NEW JERSEY

Newark—Clifford R. Lincoln, Director, 4th Floor, Gateway Building, Market Street & Penn Plaza 07102, Area Code 201 Tel 645-6214, FTS 341-6214

NEW MEXICO

Albuquerque—William E. Dwyer, Director, 505 Marquette Ave., NW, Suite 1015, 87102, Area Code 505 Tel 766-2386, FTS 474-2386

NEW YORK

Buffalo—Robert F. Magee, Director, 1312 Federal Building, 111 West Huron Street 14202, Area Code 716 Tel 842-3208, FTS 432-3208

New York—Arthur C. Rutzen, Director, 37th Floor, Federal Office Building, 26 Federal Plaza, Foley Square 10007, Area Code 212 Tel 264-0634, FTS 264-0600

NORTH CAROLINA

Greensboro—Joel B. New, Director, 203 Federal Building, West Market Street, P.O. Box 1950 27402, Area Code 919 Tel 378-5345, FTS 699-5345

***Asheville**—151 Haywood Street 28802, Area Code 704 Tel 254-1981, FTS 672-0342

OHIO

Cincinnati—Gordon B. Thomas, Director, 10504 Federal Office Building, 550 Main Street 45202, Area Code 513 Tel 684-2944, FTS 684-2944

Cleveland—Charles B. Stebbins, Director, Room 600, 666 Euclid Avenue 44114, Area Code 216 Tel 522-4750, FTS 293-4750

OKLAHOMA

***Oklahoma City (Dallas, Texas District)**—4020 Lincoln Boulevard 73105, Area Code 405 Tel 231-5302, FTS 736-5302

OREGON

****Portland**—LLoyd R. Porter, Director, Room 618, 1220 S.W. 3rd Avenue 97204, Area Code 503 Tel 221-3001, FTS 423-3001

PENNSYLVANIA

Philadelphia—Patrick P. McCabe, Director, 9448 Federal Building, 600 Arch Street 19106, Area Code 215 Tel 597-2850, FTS 597-2866

Pittsburgh—Newton Heston, Jr., Director, 2002 Federal Building, 1000 Liberty Avenue 15222, Area Code 412 Tel 644-2850, FTS 722-2850

PUERTO RICO

San Juan (Hato Rey)—Enrique Vilella, Director, Room 659-Federal Building 00918, Area Code 809 Tel 763-6363 Ext. 555, FTS 759-7040/45

RHODE ISLAND

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